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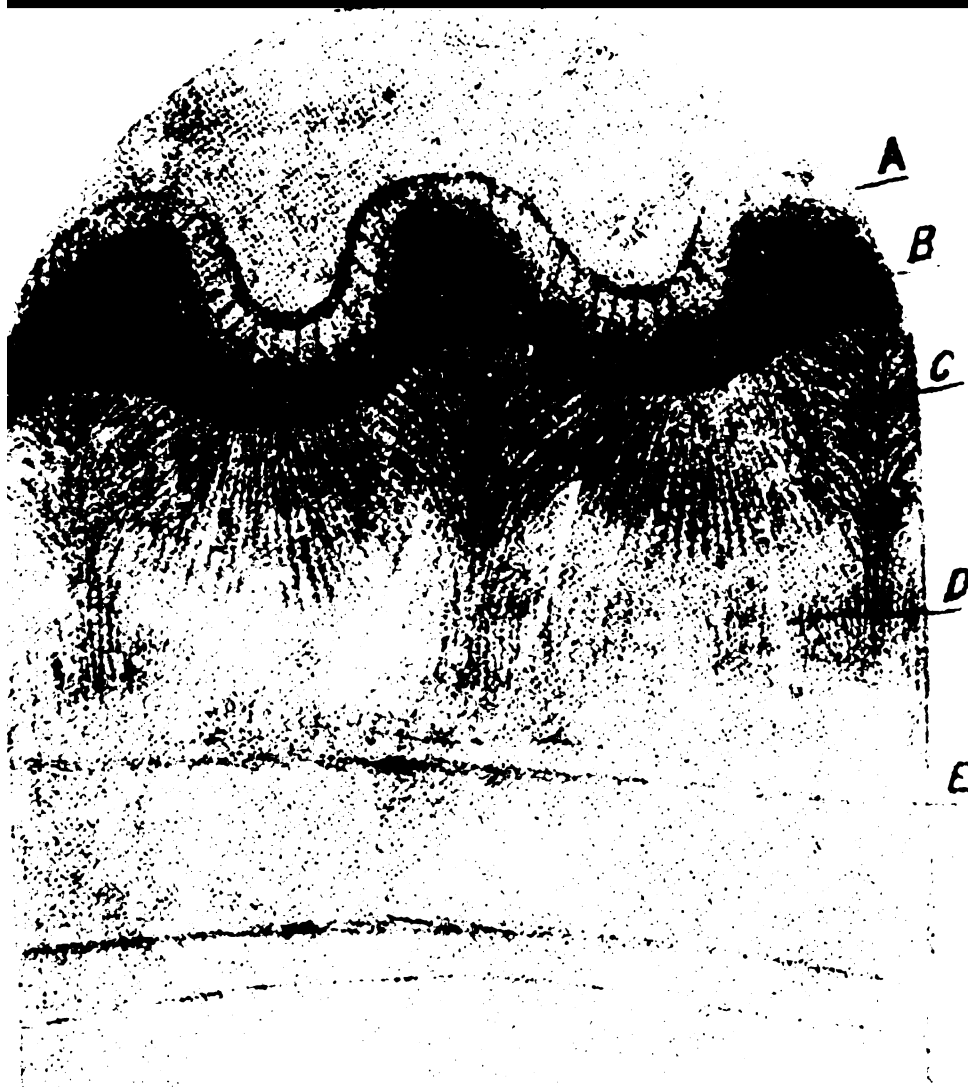
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*Journal and proceedings of the
Royal Society of New South ...*

Royal Society of New South Wales

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Mar. 30 - Aug. 7. 1889

JOURNAL
AND
PROCEEDINGS
OF THE
ROYAL SOCIETY
OF
NEW SOUTH WALES,
FOR
1888.
INCORPORATED 1881.

VOL. XXII.

EDITED BY
THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS
MADE AND THE OPINIONS EXPRESSED THEREIN.



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NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia," after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

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The Royal Society of New South Wales.

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ANNIVERSARY ADDRESS.

By C. S. WILKINSON, F.G.S., President.

[*Delivered to the Royal Society of N.S.W., May 2, 1888.*]

WE are met together this evening to commemorate the sixty-seventh anniversary of the Royal Society of New South Wales. On such an occasion it is customary to take a retrospect of the Society's proceedings during the year. In doing so our thoughts are at once directed to those who have passed away from us by death since our last Anniversary Day.

Ordinary Members.—Hon. WILLIAM BUSBY, M.L.C., elected 1875 ; Messrs. EDWIN DAINTRY, elected 1873 ; AUGUST DUCKERSHOFF, M.D., Leipzig, elected 1882 ; H. S. HAWKINS, M.A., elected 1877 ; ARTHUR T. HOLROYD, M.D., Edin., F.L.S., F.Z.S., elected 1876 ; ARTHUR LEVETT JACKSON, elected 1878 ; GEO. KNOX, M.A. (Cantab.), elected 1874 ; JAMES MANNING, elected 1873 ; JAMES MARKEY, L.R.C.S., Irel., L.R.C.P., Edin., elected 1878 ; CHRISTOPHER ROLLESTON, C.M.G., elected 1856 ; JAMES BURLEIGH SHARP, J.P., elected 1876 ; WILLIAM TUCKER, elected 1868 ; W. G. WESTON, elected 1877.

Honorary Members.—Prof. L. G. DEKONINCK, M.D., Liège, elected 1876 ; Sir JULIUS VON HAAST, K.C.M.G., Ph.D., F.R.S., elected 1880.

Corresponding Member.—F. B. MILLER, F.C.S., elected 1880.

The Hon. WILLIAM BUSBY, M.L.C., born 1812, died 23rd June, aged 75.—The Hon. William Busby came with his father in the year 1824 from England. Mr. John Busby was the first

A—May 2, 1888.

civil engineer to practice his profession in Sydney ; he received the appointment of Mineral Surveyor to the Government, and when Sir Thomas Brisbane arrived his skill was utilised to search for water for the supply of Sydney. The result was the construction of Busby's Bore, whereby a tunnel was made from the Lachlan Swamp to Hyde Park. In this work Mr. William Busby acted as Clerk of the Works, during the period of its construction from 1827-1837. In length it is $2\frac{1}{4}$ miles, with a section of 4 feet by 5 feet. The delivery of water averages 3 to 400,000 gallons daily, which was sufficient for the then population of 20,000.

On the completion of this important engineering work, Mr. William Busby engaged in pastoral pursuits in the Northern Districts and met with considerable success. Some little time previous to his death he was in ailing health, but the end was hastened by a severe chill. He died on Thursday, 23rd June, aged 75 years. He was esteemed by a large circle of friends, and as a Member of the Legislative Council, to which he was elected in 1867, he gave close and regular attention to everything that tended to the public good. He joined this Society in 1875.

ARTHUR TODD HOLROYD, born 1st Dec., 1806 ; died 15th June, 1887 ; aged 81.—Mr. Arthur Todd Holroyd was born in London, and educated at Ripon Grammar School. At 18 years of age he commenced to study medicine, first at Cambridge and then at Edinburgh, where he took his M.D. degree in 1830. He however preferred the legal profession, and entered at Lincoln's Inn, but wishing to travel before being called to the Bar, in 1835 he visited Rome and Egypt. He penetrated beyond the great desert into the Soudan, and as one of the earliest of English travellers, passed over the same route as General Gordon traversed to Khartoum. He thence journeyed down the Blue Nile to Senaar, crossed the desert to the White Nile, thence to Kordofan and Cairo. From his personal witness of the extent of the slave trade he was able to make representations to the British Government in aid of its suppression. In 1838 he visited Palestine and Syria ; unfortunately

no record of his travels exists in print. In 1843 he landed in New Zealand where he remained two years, and then came on to Sydney where he was admitted to the Bar. In 1851 he was elected to represent Bathurst in the Old Legislative Council, and helped to introduce various reforms. He became a member of the First Legislative Assembly, and in 1860 occupied the post of Chairman of Committees. In 1863 he accepted office in the Martin Ministry as Minister for Works. In 1866 he was appointed Master-in-Equity, and in 1879 Acting Supreme Court Judge. He was a Fellow of the Zoological Society (London) since its commencement in 1827, of the Linnean Society (London) since 1829, and of the Royal Geographical Society since 1839. He joined this Society in 1876.

In farming matters he was an enthusiast. One of his earliest ideas was the introduction of flower culture, and in the growth of choice varieties of fruits he laid great stress, having imported the best stocks from Europe. In order to improve the land by draining, he established the manufacture of drain-pipes and eventually fancy tiles, etc., at the well-known Sherwood Drain and Tile Works.

From 1867 to 1877 he held the position of District Grand Master of English Freemasons in this Colony, and his ability as an Administrator was apparent in the success of the Society.

Although past 80 years of age, he was strong and active to within a few weeks of his end, and he passed away on Wednesday, 15th June, from the decay of old age.

CHRISTOPHER ROLLESTON, C.M.G., born 1817 ; died 9th April, 1888 ; aged 71. Mr. Christopher Rolleston was my immediate predecessor in the Presidential Chair. It was this time last year that he delivered an Address reviewing the general scientific advance of the year.

You are, doubtless, well aware of his public life. He was born in Nottinghamshire in 1817, arrived in N. S. Wales in 1838, and

engaged for five years in farming on the Hunter. In January, 1843, he was appointed Commissioner for Crown Lands for Darling Downs. In January, 1855, he became Private Secretary to Sir Wm. Denison. In March, 1856, he was made Registrar-General and inaugurated the present system of registration. In 1858 the Statistical Register was first published, and the Registration of Deeds transferred to his department. In 1862 the Real Property Act was passed, and its introduction devolved upon him. In November, 1864, he was appointed Auditor-General. In 1870 the present Audit Act was passed. In 1874 he was created C.M.G., and retired from the Public Service in 1883.

He took an active interest in the work of the University, and on the Boards of Insurance Companies and the Mercantile Bank his financial talents found scope. He was elected a Member of the Philosophical Society of N.S.W., and contributed several papers to the Society: 1868—"On the Results of Wheat Culture in N.S.W. for the last ten years." 1870—"On Post Office Savings Banks, Friendly Societies, and Government Life Assurance." 1870—"Statistical Review of the Progress of N.S.W., 1862-1871." 1874—"Criminal Statistics of N. S. W. from 1860 to 1873." 1878—"Anniversary Address." 1882—"Notes on the Progress of N.S.W. during the years 1872-1881." 1883—"Anniversary Address." 1887—"Anniversary Address."

He had accepted a position on the Committee of the Australasian Association for the Advancement of Science, but resigned from a desire to lessen his engagements. On 6th April he was seized with a sudden attack of illness which speedily developed into alarming symptoms, so that no hope was entertained of his recovery. His invariable kindliness of disposition won the affection of all who had the pleasure of his acquaintance, and his death will long be felt by a large circle of friends.

LAURENT GUILLAUME DE KONINCK, M.D., was for many years Professor of Chemistry in the University of Liège, but is far better known as a Stratigraphical Geologist and Palæontologist. His chief works have reference to the fossils of the Carboniferous

Period of Belgium, but he has also contributed several memoirs on those of the Eastern Hemisphere.

His first important work was "*Description des Animaux Fossiles qui se trouvent dans le Terrain carbonifère de Belgique*" (2 vols. and supt., Liège, 1842-57). This was followed, and to some extent ran concurrently with his "*Monographie du Genre *Productus**" (8vo., Liège, 1846), which is of interest to Australian students as containing the description of the Australian species of that genus. In 1872, Prof. de Koninck published his "*Nouvelle Recherches sur les Animaux Fossiles du Terrain carbonifère de la Belgique*" (4to., Bruxelles, 1872), in which a revised description of the Belgian Carboniferous Coal-fauna was given. To workers in this continent, however, by far the most valuable of all this eminent observer's works is his "*Recherches sur les Fossiles paléozoïques de la Nouvelle Galles du Sud*" (2 vols. 4to., Bruxelles, 1876-77).* This is a description of the gatherings of the late Rev. W. B. Clarke, extending over a long series of years; and it is deeply to be regretted that the result of so much profound study was wholly consumed in the unfortunate Garden Palace fire in 1882. This is the more deeply to be deplored when we remember that the fossils in question formed the types of many new species, hitherto unknown to Science, and of which many specimens have not since been obtained. Of all his publications, however, that which will carry his name down to posterity as his "*magnum opus*" is that truly magnificent work, "*Faune du Calcaire Carbonifère de la Belgique*," published in folio in the '*Annales du Musée Royal d'Histoire Naturelle de Belgique*' (folio, Bruxelles). He died, July 16th, 1887.

Sir JOHN FRANCIS JULIUS VON HAAST, K.C.M.G., Ph.D., F.R.S., &c., was Professor of Geology in Canterbury College, Christchurch, New Zealand, and Director of the Museum.

*An English translation of this work, with plates, edited by Mr. Robt. Etheridge, junr., Palæontologist, is in course of publication by the Department of Mines, Sydney.

During the first portion of his residence in New Zealand he was occupied in geological surveys in the Province of Canterbury, and on which he published several voluminous Reports, the most important being "Geology of the Provinces of Canterbury and Westland" (8vo., Christchurch, 1879).

Dr. Haast's early geological observations were, in a great measure, made on the glacial phenomena of the Southern Island of New Zealand. During later years, when not occupied with the improvement of his Museum, he devoted himself to the investigation of the Extinct Wingless Birds, and on which he wrote several important papers. Amongst these we may mention "Researches and Excavations carried on in and near the Moa-bone Point Cave, Sumner Road, 1872," which gave rise to much discussion at the time of its publication. Several papers were also written by Dr. Haast on the living Avifauna, Fish, and Cetacea of New Zealand; and we are indebted to him for a contribution to the study of its Extinct Reptilia.

At the Indian and Colonial Exhibition, held in London in 1886, Dr. Haast acted as New Zealand Commissioner, and gave ample testimony of his abilities as an organizer and administrator. For these services he received the honour of Knighthood. He died, August 15th, 1887.

FRANCIS BOWYER MILLER, died 17th September, 1887, aged 58. Mr. Miller was educated at King's College, London, and after having accompanied an expedition to the West Coast of Africa, came out to this Colony in 1854, having received the appointment of Assayer to the Sydney Branch of the Royal Mint on its formation. He remained in the service of the Sydney Mint until 1870, when he was transferred to Melbourne on the formation of the Branch in Victoria, receiving at the same time promotion both in position and salary. On the retirement of Major-General Ward in 1878, Mr. Miller was again promoted, and was twice appointed Acting Deputy Master in charge of the Melbourne Mint. He is well known to the scientific world as the inventor of the chlorine process of refining gold, which has ever since been

in constant use in the Sydney and Melbourne Mints. This invention caused a complete revolution in the treatment of the precious metals, and has been of great advantage to the Colonial Mints, and of considerable profit to the mining interests; but, like many other originators of most useful inventions, he reaped but a comparatively small reward for his important and valuable discovery. Mr. Miller was a Fellow of the Chemical Society of London, and a Corresponding Member of the Royal Society of N.S.W.

At the end of last year, there were 488 Members on the roll. Of these, thirteen have been removed by death; seven have resigned; and ten have ceased to be Members through non-compliance with the Rules of the Society. Twenty-four new Members have been elected during the year; so that the total number of Members on the roll on 30th April, 1888, is 482.

Michael Foster, M.D., F.R.S., Professor of Physiology, University of Cambridge, was elected an Honorary Member on 4th May, 1887.

During the past year the Library of the Society has been enriched by the donation of 1244 Volumes and Pamphlets, two Portfolios of Charts, and 30 loose Charts.

During the past year the Society presented its Journal and Proceedings. Vol. XX. for 1886, to 342 Societies and Institutions, and Vol. XXI. for 1887, to 338, of which a list has been published.

The following new Societies have entered into an exchange of publications since last year, viz: Society of Natural History, Brookville, U.S.A.; Editor of the Journal of Comparative Medicine and Surgery, New York; Wagner Free Institute of Science, Philadelphia; Deutsche Seewarte, Hamburg; German Meteorological Society, Hamburg; Vereins für Erdkunde, Leipzig; Sociedad Científica "Antonio Alzate," Mexico; Sociedad Científica Alemana Santiago de Chile; Société des Naturalistes, Kieff, Russia.

The Society has subscribed to 49 Scientific Journals and Periodicals, and has purchased 90 volumes at a cost of £67 5s. 3d., including Vols. I. to XXXVII. of the Palaeontographical Society's publications.

During the past session the Society held eight Monthly and one Special Meeting, at which the following papers were read:— 1887, May 4—Presidential Address, by Christopher Rolleston, C.M.G. June 1—"Recent work on Flying Machines," by Lawrence Hargrave; "Some N. S. Wales Tan Substances, Part I." by J. H. Maiden, F.R.G.S. July 6—"Notes on the experience of other countries in the administration of their Water Supply," by H. G. McKinney, M.E., M.I.C.E. August 3—"Notes on some inclusions observed in a specimen of the Queensland Opal," by D. A. Porter; "Some N. S. Wales Tan-substances," by J. H. Maiden, F.R.G.S.; "The Influence of Bush Fires in the Distribution of Species," by Rev. Robert Collie, F.L.S. September 7—"Origin and mode of occurrence of Gold-bearing Veins, and of the Associated Minerals," by Jonathan Seaver, C.E., F.G.S.; "Results of observations of Comets VI. and VII., 1886, at Windsor, N.S.W." by John Tebbutt, F.R.A.S. October 5—"Port Jackson Silt Beds," by Fred. B. Gipps, C.E.; "Some N. S. W. Tan-substances, Part III." by J. H. Maiden, F.R.G.S. November 2—"On the presence of Fusel Oil in Beer," by William M. Hamlet, F.C.S. December 7—"Some N. S. W. Tan-substances, Part IV." by J. H. Maiden, F.R.G.S.; "Autographic Instruments used in the development of Flying Machines," by Lawrence Hargrave.

The Medical Section held seven meetings, fourteen papers read; Microscopical Section, eight meetings; Sanitary Section, four meetings, five papers read.

The Sanitary Section, after a lapse of seven years, was revived in 1886. Since then ten meetings have been held, when excellent papers on sanitary subjects have been read by:—Trevor Jones; Reuter E. Roth, M.R.C.S.E.; Dr. Quaife; Dr. Ashburton Thompson; G. W. Redfern; T. B. Henson, C.E.

At the Council Meeting, held on the 14th December, 1887, it was unanimously resolved to award the Clarke Medal for the year to the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.

A more appropriate award of this Medal could not have been made. During the last thirty-one years the Rev. Tenison Woods has been well known as a writer upon the Natural History of Australasia. Of his 157 works published since the year 1857 no less than 74 are upon his favourite branch of Science—Geology. I well remember with what interest and profit I first read in 1864 his valuable work, *Geological Observations in South Australia*, and I know that my experience is that of many, for wherever I have travelled I have found his name a household word, so wide an influence have his writings exercised among all classes. His name may be justly associated with that of the venerated geologist, whose life work in Australia this Medal commemorates. We all deplore the illness which prevents him from being present here this evening.

In response to the offer of prizes and its Medal by the Society for communications containing the results of original research or observation upon given subjects, the following were received :—

On the Silver Ore Deposits of N.S.W.	1 paper
Origin and Mode of Occurrence of Gold-bearing Veins and of the Associated Minerals	7 papers
Influence of the Australian Climate in producing Modifications of Diseases	1 paper
On the Infusoria peculiar to Australia	<i>Nil.</i>

The Council at its Meeting on the 27th July, 1887, awarded the prize of £25 and the Society's Medal, which had been offered for the best communication on the "Origin and Mode of Occurrence of Gold-bearing Veins and of the Associated Minerals" to Mr. Jonathan C. B. P. Seaver, C.E., F.G.S., M.P.

The Council has since issued the following list of subjects, with the offer of the Society's Bronze Medal and a prize of £25, for each of the best researches if of sufficient merit :—

SERIES VII.—To be sent in not later than 1st May, 1888.

No. 24.—Anatomy and Life History of the Echidna and Platypus.

25.—Anatomy and Life History of Mollusca peculiar to Australia.

26.—The chemical composition of the products from the so-called Kerosene Shale of New South Wales.

SERIES VIII.—To be sent in not later than 1st May, 1889.

No. 27. On the Chemistry of the Australian Gums and Resins.

28.—On the Aborigines of Australia.

29.—On the Iron Ore deposits of New South Wales.

30.—List of the Marine Fauna of Port Jackson, with descriptive notes as to habits, distribution, &c.

SERIES IX.—To be sent in not later than 1st May, 1890.

No. 31.—Influence of the Australian climate, general and local, in the development and modification of disease.

32.—On the Silver Ore deposits of New South Wales.

33.—On the Occurrence of Precious Stones in New South Wales, with a description of the deposits in which they are found.

I am happy to have to congratulate the members upon the favourable financial statement of the Hon. Treasurer, Mr. R. Hunt, F.G.S., which has been submitted to you by the Council.

From this it will be seen that, after transferring £19? to the Building and Investment Fund, a balance of £59 18s. 6d stands to the General Account for the next year. The Building and Investment Fund now amounts to £384 11s. 1d., which is invested in fixed deposit.

Until last year the Society's Journal had been printed at the Government Printing Office ; but the Government having notified that this practice would be discontinued, it devolved upon the Society to undertake the work at its own expense. The thanks

of the Society were tendered to the Government for the great privilege it has hitherto enjoyed.

We are glad, on this our first General Meeting since his return, to welcome back Professor Liversidge in good health. We feel sure, knowing his deep interest in the Society's welfare, that his tour through Japan, America, England, and Europe, affording opportunity for meeting his *confrères* in Science, and visiting some of the principal Scientific Institutions in the old world, will not only have been of interest to himself, but of advantage to this Society. But for the unremitting attention and energy of Mr. F. B. Kyngdon and Mr. S. H. Cox,—the other Hon. Secretaries, to whom our thanks are specially due,—I fear that in the Professor's long absence we should have experienced somewhat the position of a ship's crew without its captain.

Another active Member of the Society, Mr. H. C. Russell, Government Astronomer, also visited Europe during the year to take part in the Congress of Astronomers lately held in Paris. We may be congratulated on again having his valued counsel and services as a Vice-President for the ensuing year.

Professor LIVERSIDGE in his Presidential address drew particular attention to the necessity for Scientific Education and to the means afforded for such education in this colony, chiefly in the Sydney University and in the Technical College. Many amongst us will, I am sure, also endorse the Professor's remarks in regard to the importance of introducing scientific teaching into our Public Schools. No doubt many a boy with latent abilities for science would rise to be a power for good to his country, were his early educational environment such as to favour the development of his faculties for scientific observation. We cannot deny that in most children the faculty for investigating objects of nature is very great; and if this faculty were directed first upon simple lines, what important avenues of usefulness might not its development lead some individuals into! Thus, to take one useful branch of science, can the elementary knowledge of sanitary laws be too early impressed upon all children whatever may be their future

avocations? For may not any individual possessed even of such elementary knowledge be the means of preventing in one or more instances the growth of germs of some disease which perhaps, originating in the stagnant water of a small house-drain, would spread through a town with such direful effect as we sometimes see to be the case, especially in reference to typhoid. Enlarged diagrams illustrative of the forms and rapid mode of growth of some of the dreaded organisms, explained with the aid of a microscope in a simple manner appropriate to the reason of a child, would afford lessons never to be forgotten, and perhaps, in many cases, would awaken more interest or wonder than that created by fairy tales (which I acknowledge has in itself a special value) and with the manifest advantage that the child afterwards realizes that his imagination has not been deceived, and that his reasoning powers have been strengthened for exercise in fields of usefulness for himself and for his fellows. We know that children often communicate to their parents at home what they learn at school, and if such elementary sanitary knowledge were more taught and disseminated, especially to the children of the uneducated classes, our Public schools would less frequently than now be closed, because they become the means, owing chiefly to the ignorance of the parents, of spreading infectious diseases amongst the children. In some less useful though, perhaps, more interesting branches of science might elementary teaching be also given. It is not, however, my present purpose to refer further to science-teaching, but to the main scope of the work of this Society—science-harvesting, the ingathering of fruit cultivated in the fields of knowledge.

The object of the Society, as stated in the Rules, is one of very wide range, viz. : "To receive original papers on Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History Productions." This plan of work has been well conceived, for commerce which is, so to speak, the physical strength of a nation, depends upon the development of the

country's natural resources, and this development must proceed proportionately as Science, Art, Literature and Philosophy are promoted. And as we see in Australia's unlimited natural stores of wealth a practically boundless field for internal and international commercial enterprise ; so we perceive the necessity, nay our duty, at the present time when the foundation of our national greatness is being laid, to determine that the gradual erection of the superstructure be carried out with the precision and solidarity that Science can demonstrate ; with the symmetry and adornment which the refining guidance of Art affords ; and with that recognition of world-wide relationship which Literature inspires ; while Philosophy, all-embracing, in giving purpose and aim to all, engenders that spirit of self-denying co-operation, which not only advances the knowledge of Truth, but also rewards each worker with the assurance of participating in the culminating unity which Truth reveals.

How, for instance, would the necessities of our iron manufacturing branches of commerce be met, if the latest scientific methods of reducing the raw ironstone to metal were disregarded for the employment of the primitive blast forges ? Is not refinement in the character of an individual or a community to be found expressed, and being expressed intensified, in exhibitions of painting, music, floriculture, and architecture—in the adornment, if only for mutual admiration and sympathy, of the varied palatial buildings which the modern exigencies of home life, trade and commerce require ? How could we have inherited that knowledge which is dispelling the darkness of ignorance and in its freedom-giving light revealing the relationship of every branch of mankind, were it not for the cultivation of Literature ? And whence would the self-sacrificing seekers after Truth derive encouragement and hope, did not Philosophy indicate the interdependence, fellowship and unity of all.

Here then is the great work for our Society—a work based upon true principles of progressive civilization, and advancing the welfare of this country, not only for the country itself, but because

of its connection with all other countries, and of its growing influence for good amongst them. Fulfilling such a position the Royal Society will, no doubt, continue to receive that private and State recognition and support which it now enjoys. But its real vitality and influence do not so much depend upon such aid, as upon the personal work of its Members, however simple or abstruse that work may be. One Member may have some important discovery to reveal; another may have but a single specimen to exhibit to illustrate, perhaps, only the mode of its occurrence: both may be equally worthy of record in the interests of Science. What a rich and vast field for scientific research have we not in this portion of the globe, on the land and in the fertile Australasian Ocean. Its tropical jungles and its alpine heights; the wide-spread open grassy plains and the splendid forest-clad mountains; its beautiful sheltered harbour inlets from the great water-way of the globe, and its interior rivers awaiting engineering enterprise to convert them into navigable highways; its varied and rich agricultural, pastoral and mineral lands, yet to be occupied by millions of people whose profitable labour therein is assuredly indicated; its low lands and high-lands ranging within both tropical and temperate latitudes, with their concomitant climates suited to incomers from almost any other part of the world; its geographical position and physical features offering for the astronomer and meteorologist a terrestrial position for celestial observation without which the science of astronomy would be incomplete; its peculiar fauna and flora embracing living forms of ancient types long extinct in other regions; its branches of the human race; its rock formations, with their included remains of the past life upon the earth, furnishing their data to render more complete the "geological record;" the shallow estuarine and deep sea resources of the surrounding ocean;—these and other interdependent objects in nature justify the most sanguine anticipations as to the great importance and interest attaching to the science work our Society has undertaken.

Nor do we forget that this Society is not alone in the field, though it is the oldest. The kindred Scientific Societies of this

Colony, as well as of Victoria, South Australia, Queensland, New Zealand, and Tasmania, are equally with us in object and aim. The twelve yearly volumes of the Linnæan Society of New South Wales afford a rich store of contributions to the Natural History of Australasia, including work of special value, as it embraces much original research.

The recently formed Economic Association, of which Dr. Maclaurin, Vice-Chancellor of the Sydney University, is President, is one which should exercise much good influence upon the present national growth of this country, its object being the discussion of questions arising out of the Science of Economics.

The Australasian Association for the Advancement of Science may now be considered established, and promise is given of its operations being attended with great success. Thirty learned and Scientific Societies in the different Colonies have joined the Association, and the majority have appointed delegates to represent them on the General Council. It is expected that all the Societies which have not yet joined will do so before the General Meeting. A satisfactory list of papers has already been received, and many other papers have been promised. A Reception Committee has been formed, and the Sectional Committees will shortly be appointed. The First General Meeting will take place at the Sydney University about the end of August, and if possible the succeeding Meetings will take place in turn in the Capitals of the other Colonies.

It would be impossible to institute a comparison as to the relative value of the work undertaken by the Sections of the Society: the work of each is essential, as a part, for the completion of the whole. But it cannot be denied that there is not a more important field for scientific investigation than that in which the members of the Medical and Sanitary Sections are engaged. The Medical Section, of which Dr. P. Sydney Jones is chairman, has been energetically at work. It would be presumption on the part of one like myself, occupied with the investigation of geological phenomena, to attempt to review the labours of those who are

working out the present life conditions of the earth : but I may say that there is no one of us but should feel a personal interest in the results of their labours, which so deeply concern the well-being of mankind. There is evidence patent to us all, even to the unprofessional, of the good progress and achievements of Medical and Sanitary Science.

The Microscopical discoveries that have been made as to the cause of many of the most malignant diseases, have revealed conditions which may be applied for the prevention, and to some extent, the cure of disease. Science and practise, by united effort, are fast reforming the sanitary conditions of our modes of living. This is apparent, for in the adoption of remedial measures the death rate in large communities has been reduced considerably. Take for instance London, which for its immense population, is one of the healthiest cities in the old world. Facts are eloquent pleaders. According to the reference in the Annual Report for 1887 of our Government Statistician Mr. T. A. Coghlan, the average death rate of London has since 1871 been reduced from 24·4 per thousand to about 21·5 per thousand, representing an annual saving of 12,000 lives, and a proportionate increase in the length of life to the living. This improvement is attributed to the carrying out of a complete system of sewerage, joined to an efficient water supply. In the same valuable report we are informed that comparing the second with the first half of the period which has elapsed since 1870, the death rate of the city of Sydney has improved about 4·5 per thousand, representing a saving of 600 lives each year, while the suburban rate has advanced nearly 4 per thousand, representing a loss of 800 lives during each year as estimated on the population of 1887. And this deplorable aspect of the state of public health in some of the suburbs, attributable to the absence of efficient sewerage and water supply, is intensified when we are told that the infantile mortality was 51·27 per cent., or more than half the total deaths, and largely preventable—the result of neglect and of ignorance. Who will come forward and help to stay this modern Herodian slaughter of the innocents? Well may Mr. Coghlan remark that the high rate of deaths from preventable

causes forms a pathetic commentary on the absence of sanitary precautions. Or regarded from another point of view: it is estimated that the value of every infant born in the Colony should be at least £40; while the average wealth per head of the community is about £345. What a loss of wealth then to the nation does not the loss of 800 lives each year in the suburbs of Sydney alone represent! By death and national weakness, this disobedience to the laws of Nature, which are the laws of God, is thus already severely visited upon us; and to what increasing extent shall we not suffer, if improvements in sanitary conditions do not keep pace with the increasing population! And further, when we find as English statistics show, that chiefly owing to the large infantile mortality, the average period of life of the wealthier and leisured classes is nearly double that of the artisan classes; that is, where the average age at death of the former is 44 years, that of the latter is only 24 years, are we not appalled at this state of things, which to some extent must always exist where population is more or less concentrated? But cannot the wide difference between the condition of these classes be greatly lessened? Who is responsible for its present state? Doubtless not only the governing authorities, but also many of the people themselves who neglect to avail themselves of the facilities afforded them by Municipal and other authorities for sanitary improvements. This language may appear too reproachful, but when Science demonstrates the cause of, and remedy for the many perishing in our very midst, it would be unworthy of one speaking from the Presidential Chair of this representative Scientific Society, did he not, in referring to this all-important subject, appeal to the sympathy and co-operation of all for immediate sanitary reform—and especially on the present occasion in this Centennial year, when the colony is priding itself upon its marvellous growth, the significant position it has attained, and the prosperous future it anticipates.

The average death-rate per 1000 of the population of New South Wales is 15.55 which compares very favourably with that

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of Great Britain, viz. 21·5, and this is lower than those of France, Germany, and other leading European countries: yet we have just seen what great improvement is possible, and if this were effected New South Wales might become one of the healthiest countries in the world; or to use the words of our Government Statistician "were it not for the pitiable waste of infant life, the death-rate of this colony would not reach more than half the European average" which is 25·63 per thousand; in fact it should not exceed the normal death-rate for New Zealand, viz., 11·33 per thousand. Evidence to the same effect is given in the "Report of the Mortality Experience of the Australian Mutual Provident Society," which deals of course with lives approved for assurance. This report by the Actuary, Mr. Maurice A. Black, states that "The one broad fact which will be found to stand out boldly throughout the whole of these pages is that the mortality experience of this Society has been more favourable than that of any other Life Assurance Office in any part of the world. This is a pleasing reflection for those colonists who have left, and an encouraging one to others about to leave the old country, presumably only to better their circumstances, to find that in their new home their lease of life will be prolonged—that the average number of years which persons of a specified age taken one with another enjoy is greater in Sunny Australia than in the cold and rainy climate of Great Britain."

I will not detain you further upon this subject, but I have made special reference to it, for it is one of such vital importance for the future well-being of this country, and it is one in which many Members of the Society may take a personal and active interest and become public benefactors. I must, however, here acknowledge the effective influence for sanitary reform of the Government Board of Health under the direction of Dr. MacLaurin, also of the Water and Sewerage Board.

Dr. Oscar Katz is engaged upon important work in his bacteriological researches which are being published by the Linnean Society.

The New South Wales branch of the British Medical Society is also doing good work. The President in his late annual address, amongst other subjects, refers to the alarming spread of rabbits over the western portion of the colony. It is a matter of grave importance and one which may well engage the attention of scientific men. Over a large area of country such as ours, it is manifestly useless to attempt to eradicate or even to stay the progress of the rabbit pest by artificial methods, for the rabbits under favourable circumstances, multiply faster than it is possible to kill them by ordinary means : it is said that the progeny of a pair of rabbits in the course of three years amount to over three millions. I have recently travelled through the Barrier Ranges and have seen them so swarming with rabbits as to lead one to believe that unless some effective remedy be employed, a large portion of the country will have to be abandoned by the pastoralists, which means immense pecuniary loss to the colony at large. The Government recognising the importance of this matter offered a reward of £25,000 for a satisfactory method of destroying the pest. This induced much attention being given to the subject both in Australia and in Europe, with the result that several natural methods have been proposed which have been deemed worthy of trial, viz., the chicken cholera disease by the eminent M. Pasteur, and another disease remedy by Messrs. Butcher and Ellis of Tintinallong. M. Pasteur has deputed three savants who are accustomed to micro-biological researches, Dr. Hinds, Dr. Loir and Dr. Germont, to demonstrate his process in this colony. It will be remembered that M. Pasteur was elected an Honorary Member of this Society at its annual meeting in May, 1883. Referring to this in a letter which I received a few days ago from M. Pasteur, he says:—
“ Dans la délibération que la savante Société a prise à cette occasion, elle a bien voulu désigner mes recherches sur la part que les organisimes microscopiques prennent au développement de diverses maladies. J'étais loin de penser alors qu'un jour viendrait où j'aurais à m'occuper d'un fléau qui désole vos

riches et immenses contreées agricoles et qui j'aurais à proposer à votre Gouvernement, pour détruire ce fléau, précisément une maladie microbienne."

I am informed by Mr. F. B. Kyngdon, Chairman of the Microscopical Section, that during the past year a gentleman resident in Sydney—Mr. Francis—found that by applying to the eye-piece of a microscope the analysing prism of the polariscope, the resolution of a high-power objective was intensified to a marked degree. The method was illustrated at the Monthly Meeting of the Royal Microscopical Society, London, in November last, and the experts present—while fully admitting the valuable results obtained when 'close-lined' tests were shown with oblique light—were unable to account satisfactorily for the optical principles upon which the advantage is based.

This method of intensifying the resolving power of microscope objectives does not endow a glass with powers beyond what it originally possesses, but it enables it to perform exceptionally well. The action, of the prism appears to prevent a slight confusion of rays which may tend to mar the best resolution. In practice this unexpected result of the prism may prove of practical benefit in the workshop of the artist who constructs those perfect specimens of human skill, the modern high power microscope objective; and it is quite possible that some advantage may be gained by its use in the laboratory of the student of Bacteria and other minute forms of life whereby a glimpse may be obtained of an otherwise nearly invisible process.

As a valuable assistance to Microscopic observers Photography is becoming more and more indispensable. The recent advance in the dry-plate process places within the reach of everybody a simple, cleanly, and most accurate method of recording results. In the study of Bacteria, micro-photography will be increasingly depended upon. Several very excellent photographs have been taken by members of our Society during the last few months, and I understand that considerable interest will be given to this subject during the coming Session of our Microscopical Section.

In Astronomical Science the year 1887 will be marked as that of the first great Conference of the World's Astronomers—a Conference called together to secure systematic and united effort in carrying out the grandest work that astronomers have ever attempted : that is, to make a complete and accurate chart of the whole heavens down to the stars of the 14th magnitude. Some idea of the dimensions of this undertaking may be gained from the fact that, as I am informed by Mr. Russell, Government Astronomer, when all who can take part in it are ready, which will probably be in the year 1889, it will take from six to eight years to get the 50,000 photographs which this work involves.

Many of these photos will record thousands of stars, and the whole record is estimated to contain 20 millions. And after that comes the labor of measuring, recording and publishing the position of every individual star ; no one yet dares to say when that will be done, but when all the labour has been done, and the few final figures for each star are printed, they alone will give about 2,000 quarto volumes of 300 pages each.

But the fact that this work is to be undertaken, marks a great step onward in the appliances now at the command of the astronomer, resulting from recent advances in photography, optical work and mechanism, but mainly in photography. Sensitive plates are now made of such marvellous quality, that stars and nebulae invisible even with the most powerful telescopes, can be photographed ; and by the aid of new appliances the veteran solar photographer "Janssen" proposes to get photos of the Sun which will reveal every detail of the changes constantly going on in it, and thus lead the way to answer the question which the meteorologist is asking, "What is going on in the Sun to account for these strange conditions of weather ? And there can be no doubt that the great impulse now given to astronomy by the work of the Paris Conference, will do very much towards tracing the solar conditions, which are of such vital importance to the inhabitants of the earth in their effect upon climate.

The meteorologist has slowly traced the phenomena of storms, and in the daily weather charts published here, and generally in Europe, we can trace the track of the storm with its concurrent weather, including rain, for several days in advance. Rain is no longer the unknown phenomena of which no explanation could be given, it is now known to hold a definite relation to the storms known technically as cyclones, and as their track can be predicted, so can the rain : it is but a step onward to unravel the cause of the cyclones of a particular season, why they follow this cause or that ; in the one case they bring abundance of rain, and in the other drought. And when that is done by the aid of astronomers, the meteorologist's prediction will take a wider range and give us the weather for the season. It requires no words from me to point out the importance of such an advance in a country where wealth and weather are so intimately related.

With the exception of a few papers by Mr. Chas. Moore, F.L.S., Baron Sir Ferd. von Mueller, and the Rev. J. E. Tenison-Woods, F.L.S., this Society has contributed but little to Botanical Science notwithstanding the large amount of work that yet remains to be done. In reference to this subject I will give you some recent observations by the Rev. Dr. W. Woolls, F.L.S., who, next to Baron von Mueller has done so much in making known the botany of this Colony, "The progress of Botanical discovery in Australia has been very marked since the beginning of this century. It was in 1805, that the eminent Botanist Robert Brown, took with him to Europe from these shores some 4,000 species of plants. Many of these were new to science, and illustrative of the vegetation peculiar to Australia. After several years of labour in arranging species and genera systematically, he laid the foundation of our Flora in his celebrated '*Prodomus Flora Novæ-Hollandiæ et Insulæ Van Diemen* in 1810,' and in so doing showed the superiority of natural to artificial systems. For more than half a century, (during which enterprising travellers and explorers added many species to those previously discovered) much valuable information respecting indigenous plants was scattered through

the works published by Oxley, King, Cunningham, Sturt, Mitchell, Leichhardt, &c. It was not however, until 1878, that Mr. Bentham, assisted by Baron Mueller, described in the seven volumes of the *Flora Australiensis* all the known plants of Australia, and thus collected together in one elaborate work after sixteen years from (1863 to 1878) of unremitting exertion a full account of our Flora as derived from all sources, whether from the accumulated collections in Europe, or from those procured by Baron Mueller in Australia. The *Flora Australiensis*, it should be observed, describes the dicotyledonous and monocotyledonous plants fully, but of the acotyledonous orders only the Lycopodiaceæ, Marsilaceæ and Filices, or what are termed the higher Vascular Cryptogams. Between 1858 and 1881 Baron Mueller published eleven volumes of his *Fragmenta Phytographiæ Australiæ*, containing descriptions in Latin of new and rare plants, and also, in the last volume, lists of the lower Cryptogams furnished from various sources. His *Eucalyptographia*, his work on the Myoporinous plants of Australia, and that, now in course of publication, on the genus *Acacia*, have contributed materially to clear up difficulties in the classification of species, and by means of well executed figures, to place before the student in almost living reality some of the most interesting of Australian plants. In his 'Systematic Census of Australian Plants,' to which he has added several supplements, he has given a comprehensive view of the Flora of Australia, showing the species peculiar to the respective colonies, and raising the total number of vascular plants to nearly 9,000. Whilst the progress of the past, especially during the last quarter of a century, has been most satisfactory, it is evident that the lower Cryptogams afford a wide field for scientific investigation; and it is to be hoped that specialists in the various departments may be found to accomplish for the Mosses, Lichens, and Fungi, what has been done so ably for the higher orders of vegetation by Brown, Bentham, and Mueller. Professor Harvey in his splendid '*Phycologia Australiæ*,' has done much for the Marine Botany of these coasts, but as he

intimates in the preface, many species of *Algae* have yet to be added to the 800 recorded by him. Baron Mueller, through the labours of Dr. Sonder, as acknowledged in the eleventh volume of the *Fragmenta*, has raised the number to 1056; but as these are given merely in lists without any descriptions, there is still a large amount of work for the phycologist to supplement the labours of Harvey. The great desideratum then at the present day is an additional volume to the *Flora Australiensis*, for the purpose of affording an account of all our known acotyledonous plants, arranged systematically, according to their orders and genera, and furnished with descriptions on a plan similar to that of the other volumes. It is doubtful whether the supplementary volume could be prepared in the Australian Colonies without reference to European Collections, as typical specimens are for the most part limited to the Museums of Europe, and the aid of eminent specialists would be required for the comparison of specimens. "Hooker's Handbook of the New Zealand Flora," affords an admirable example of what may be done for our lower Cryptogams, for although that illustrious author modestly acknowledges, that "many years may elapse before the multitudinous New Zealand genera and species of these very obscure tribes of plants are fully known," he has given excellent descriptions of all the commoner and conspicuous ones, and left it for future specialists to fill up the grand outline which he has so scientifically delineated.

In Physics and Mechanics there is a wide scope for practical science work in this new country. I will but allude to one branch of Physics—Electricity. It is not quite 51 years since Wheatstone and Cooke made their successful practical experiment of telegraphing over a distance of two miles. Now every civilized country is becoming netted, as it were, with wires for Telegraphy. Our own Colony has shared in this spirit of progress, and possesses more than 20,000 miles of telegraph lines. It is only 38 years since the first cable was laid between England and France; at the present day the length of the submarine cables would girdle the earth five times. A message can be sent round the World in

twenty minutes; and by a single wire five messages can be sent in one direction. When we consider this, and the marvellous applications of Electricity in the production of light, sound, heat, and motive power, we stand amazed at the prospect of possible discoveries yet to be made for our individual benefit and for the unification of mankind.

It augurs well for the future of this Colony that the Sydney University has provided for efficient teaching in these subjects and in Engineering. It is to the University, and also to such Institutions as the Technical College that we look to the future for well trained observers, whose scientific researches it will be the object of this Society to record.

Geology and Chemistry as applied to Mining and Agriculture may well engage the attention of this Society. Investigation in this direction will assuredly lead to results of much pecuniary advantage to those whose occupation lies in the development of two of the greatest industries of New South Wales. The knowledge of the modes of occurrence of mineral deposits will often afford a guide not only in the search for minerals, but also in conducting mining operations, especially when faultings in the strata or other difficulties occur. And the successful treatment of the complex ores, which many of the more simple or oxidized ores will pass into as the lodes are followed down, must depend upon careful management under proper chemical and metallurgical direction. Such management will no doubt also lead to the utilization of the by-products and the consequent introduction of new industries. It is satisfactory to see the announcement that, with the view of aiding in the development of mining, the Minister for Mines proposes to establish central testing works where bulk samples of ore can be treated. The little book "*Mines and Minerals*" lately published by two of our members; Messrs. S. H. Cox and F. A. Ratte, affords valuable geological instruction for miners.

A second edition of the "*Mineral Products, Geology, and Coal Mining of New South Wales*," by Harrie Wood, C. S. Wilkinson,

and John MacKenzie, has recently been issued by the Department of Mines ; and a new edition of "*The Minerals of New South Wales*," by Professor Liversidge, M.A., F.R.S., has just been published.

Some idea may be formed of the importance of the mining industry from the statistics given in the Annual Report of Mr. Harrie Wood, Under-Secretary for Mines. It is stated that the value of the mineral production for the year was £3,165,938, and that of the total production of minerals to the end of 1887, £72,938,124.

Then as to Agriculture. A glance at the geological map will show that about one-half of the area of the Colony consists of formations which produce soils suitable for cultivation. And as these formations occur at all altitudes up to 7,000 feet above sea level, and under nearly every condition of climate—from the almost tropical atmosphere of the Clarence and Richmond River Districts to the cold air of the Kiandra Mountains ; and from the humid atmosphere of the coast lands to the dry air of the interior, with a variable rainfall throughout as indicated on the Government Astronomer's map—almost every class of agriculture may be carried on. The importance of this is enhanced from the fact that the principal districts are either within easy access of waterway to the ocean, or within one day's journey by rail from the Metropolis. The value of the Agricultural production for the year 1887-8 is about £3,600,000.

It is, therefore, a matter of great moment that scientific observations should be made in numerous localities as to the average and periodic rainfall ; the character of the soils by analysis, whether deficient or not in the elements necessary for the growth of certain kinds of agricultural produce ; the effects of cross-fertilization upon certain plants ; to ascertain the nature of plant diseases ; and to determine, with a view to forest culture, what species of timber trees and trees producing tanning-bark are most suited for each district.

Mr. J. H. Maiden, Curator of the Technological Museum, Sydney, has contributed to this Society several valuable papers upon the Tan-substances obtained in New South Wales. And Mr. Angus Mackay, under the auspices of the Board of Technical Education, has been doing good work in lecturing in the principal farming districts upon agricultural science. But practical experience founded upon scientific observation is specially needed, and such might well be obtained on the experimental farms which it is said the Government is about to establish in the different districts.

For geological investigation, New South Wales presents a region of unsurpassed interest—an interest of a three-fold character, as viewed in its purely geological, palæontological, and mining or economic aspects.

The surface features of the Colony—comprising plains, mountains, and precipitous ravines—are composed of rock formations, which extend beyond the lines marking the political bounds of N. S. Wales, and connect with others to form a union of great value in aiding the completion of the Geological Record as revealed in the various land surfaces of the globe.

The geology of our Colony, therefore, to be rightly understood, must be studied in connection with that of the other Colonies; and in like manner our Australian Continent, though so isolated, is indispensable as a field for research before a true interpretation of the geology of the earth can be arrived at. Thus Geological Science not only compels a union of workers in the different provinces of Australia, but throughout the world, and in this union each worker is rewarded by a sense of the value of his share in the progress achieved.

New South Wales affords a field of wide extent as yet but little explored. Notwithstanding all that has been done, including the life-long labours of the late Rev. W. B. Clarke, who laid the foundation-stone, so to speak, of Australian Geology, even the foundation itself is at present incomplete.

On another occasion I purpose referring to the history of geological exploration in Australia,—a history recording the work of such illustrious men as Strzelecki, Grange, Stutchbury, Dana, Jukes, Darwin, Gould, Hardman, Murray, Brown, Selwyn, Tate, Tennison-Woods, Daintree, and especially the Rev. W. B. Clarke, whose memory is cherished, not only in this Society, for his beloved character and devotion to Science, but also in the hearts of the toiling miners, and of his many friends throughout this country.

But in addressing you this evening, I wish to draw attention not so much to past labours in the field of Geology, as to some of the work that has yet to be accomplished; and let me say what a splendid work it is—so attractive in scientific interest, and so conducive to results of practical importance in the development of the natural products of the colony. The palæozoic formations offer the most extensive range for investigation, almost throughout the whole series evidence of ancient organism is abundant. But though numerous collections have been made and described, so little is known that not even the limits of the several formations have yet been assigned; nor are we in a position at present to indicate with certainty which are the oldest rocks in Australia. In South Australia, Professor Ralph Tate has found limestone below beds containing the Cambrian Fossils discovered by Mr. O. Tepper; and some metamorphic rocks in Western Victoria are believed by Selwyn to be pre-Cambrian or Laurentian; but the gneissoid mica and hornblende schists, and limestone of the Barrier Ranges, which have a very ancient appearance, have yet to be determined. Nor can this be arrived at until more extensive palæontological examination, and sections of the strata from actual survey have been made. The same observations will apply in regard to the enormous development, especially in Eastern Australia, of fossils of Lower and Upper Silurian, Devonian, Carboniferous, and Permian Ages have been obtained. The only two horizons actually determined as yet are on the authority of Professor McCoy—the Llandello in Victoria;

noticable from its graptolites, and the Upper Silurian, probably Wenlock and Ludlow, also in Victoria, the latter undoubtedly extending into New South Wales.

To add to the perplexity some of the strata contain fossils characteristic of the formation below them mingled with others belonging to the overlying series : these have been named by the Rev. W. B. Clarke "passage beds" for the sake of convenience for classification. Nor have the natural thickness and order of sequence of the strata composing each series been ascertained ; their associated minerals and fossils have been but little determined ; their position and extent require mapping out ; and the suitability of their soils for agricultural and pastoral purposes is not yet fully known. I may here, in passing, say that an accurate survey of the Coal Measures in the Maitland district has just been completed by Mr. T. W. E. David, B.A., F.G.S., Geological Surveyor. This locality was selected by me for a detailed Geological Survey because the Middle and Lower Coal Measures are therein well represented ; for it is only by careful survey of such typical localities that information of value can be acquired for the elucidation of the same Coal Measures elsewhere. It is gratifying to know that Mr. David's work has been very useful, not only in scientific results as regards the order of sequence of the different strata and of their associated fossil remains ; but also from a direct practical point of view, in the discovery of two coal seams which have since been opened for mining operations. I mention this as an instance of the importance of scientific work, such as it is the object of our Society to promote, which may especially "tend to develop the resources of Australia, and to illustrate its Natural History and Productions."

Then again the geology of the Clarence River series and of the Narrabeen Shale beds requires investigation, and the succeeding Hawkesbury Sandstone formation upon which Sydney stands and whose yellow rock cliffs give such picturesqueness to our coast and harbour scenery and to the valleys in our Blue Mountains

has not been fully explored. Its economic productions of the finest building stones and brick and pottery clay shales are of great value, as the fine public buildings in the city will testify : its geological characteristics and palæontological treasures are of special interest ; though these have for many years engaged the attention of geologists it is but recently that from the rocks of Gosford one of the finest collections of fossil fishes has been brought to light : while, about the same time, the important discovery was made of *Labyrinthodon* remains, which have been described by Professor W. J. Stephens, M.A., and figured in the Proceedings of the Linnean Society. These with similar recent discoveries in the lacustrine Wianamatta shales justify anticipations of further finds of interest.

The next series of strata requiring investigation are those of the so-called Cretaceous age. I say "so-called" for they have been only provisionally assigned to the Cretaceous period, as a portion of the series, notably in Western Australia, may be of Jurassic age ; as yet very little is known about them. They occupy some 40,000 square miles in New South Wales and nearly if not quite half the Australian continent, so that they afford an immense area for examination. They are of great economic importance ; for the strata composing them offer favourable conditions for the occurrence of artesian water, which has been proved, not only in this colony but also in Queensland and South Australia, in bores varying from 110 to 1600 feet deep, splendid water issuing from these, and flowing freely from the pipes, in one instance at a height of 60 feet above the surface of the ground.

Artesian water in this formation was first obtained by Mr. David Brown in 1880, in bores put down close to some "mud springs" which are natural artesian springs on Kallara Station, in the Darling District. Observing from the Geological Map, by the Rev. W. B. Clarke, that this formation extends almost throughout the North Western portion of the colony, I, in conjunction with Messrs. Gilliat and Bruce in 1880, advised the

Government to put down a series of bores for artesian water, with a view of opening up a new and well-watered stock route from Mount Brown Gold Field to Bourke, to lead the northern traffic to the railway terminus at Bourke. These borings have been successful and in the last bore put down near the Paroo, under the direction of Mr. W. H. J. Slee, Superintendent of Drills, a splendid supply of water rising to a height of 30 feet above the surface was struck at a depth of 940 feet. In 1881 Mr H. Y. L. Brown, then one of our geological staff and now Government Geologist of South Australia, examined this portion of New South Wales and reported as to the Cretaceous formation and the certainty of obtaining artesian water in it. Mr. H. C. Russell, Government Astronomer, has also pointed out that the rainfall over the Darling water-shed does not flow away in the river channel but passes underground. In referring to this subject it is right to mention, though I was only lately made aware of the fact, that so far back as 1862 Mr. Richard Bennett, of Victoria, wrote an admirable letter to the *Economist* advocating the search for artesian water in this country.

Mr. R. L. Jack, Government Geologist of Queensland, who has issued a valuable work on the geology of that colony, states that the "Desert Sandstone," so named by Daintree, may be of Cretaceous age and is of so porous a character that it acts like a sponge in absorbing rain-water which issues as permanent springs where it rests upon the impermeable clay beds.

The Cretaceous formation supports good pasturage for sheep, cattle and other stock, but with the exception of a few localities such country, occurring as it does in the arid parts of Australia, is naturally devoid of permanent surface water. So that where most wanted the supply may be obtained from underground sources and by enterprise this dry country may be made to abound in overflowing and inexhaustible wells of good water. The wide scope which nature has afforded for scientific work in the improvement and profitable occupation of this country I need not point out.

The Tertiary formations are perhaps better known than those to which I have already referred. More attention has been given to them on account of the rich gold-bearing, stream tin and diamondiferous deposits which they contain. Nevertheless, not only has very much to be done in the way of elucidating the modes of occurrence of the deposits themselves and the nature of their embedded fossils; but the interest attaching to the work is increased by the discovery, which such work leads to, that the rich deposits are far from being exhausted. Mr. T. W. Edgworth David's geological survey of the Vegetable Creek Tin-field has shown that there are 49 miles of stanniferous deep leads of which only about three miles have been worked out since the commencement of tin mining in 1872. During this period tin ore to the value of £1,975,560 has been raised from the deep leads and shallow drifts in this district. Similar geological observations in reference to the gold as well as the tin bearing deposits have been made by myself and the officers of our Survey in other mining districts, proving that the deep leads will afford employment for miners for many years. These ancient fluviatile deposits have been extensively covered with basaltic rocks, indicating volcanic activity at different times during the Tertiary period. Two of the most remarkable of the points of eruption in New South Wales are Mount Conoblas near Orange, and Ben Lomond in New England. The microscopic examination of our various igneous rocks especially those associated with the occurrence of gold, is at present engaging the attention of the Geological Surveyors. Professor Liversidge has already communicated to this Society the results of some good work in this direction. The subject needs the co-operation of many more observers; and it is one which other microscopists of this Society might readily take up.

Few of the geological periods possess greater scientific interest than the Post Tertiary or Pleistocene. In it the characteristic fauna of Australia enjoyed a flourishing state of existence, as evidenced by the vast number of marsupials, some of gigantic

growth, that lived during this period. Their fossil remains, associated with those of crocodiles, were found in abundance at Cuddie Springs on the Gilgoin Station, near Brewarrina; and recently my geological collector, Mr. Charles Cullen, through the kind permission of Mr. M'Donald of the Myall Creek Station, near Pingera, has obtained from an alluvial deposit a unique and splendid collection of fossil bones which I am sure would more than gladden the eyes of that eminent Palaeontologist, Sir Richard Owen, to whom we are so deeply indebted for our knowledge of the interesting life history of the Pleistocene period in Australia.

The question will, no doubt, be asked by many, How is it that such remarkable animals existed in numbers throughout Australia at this period, and that, with the exception of a few species, they have since become extinct? Geology gives the answer, and Astronomy, in reference to the Earth's relation to its orbit, helps to explain it. The alluvial deposits of diluvial origin forming our vast Western Plains; those high terrace banks of gravel along our river valleys; the deeply eroded ravines carved out on the sides of our mountains—all plainly tell of a time of great rainfall since the Pliocene period. The heavy precipitation then covered Mount Kosciusko and other of our Alpine peaks with perennial snow; strong rivers coursed down the valleys, and their flood-waters, reaching the low-lying country and becoming confluent, spread out far and wide over it and deposited their burden of muddy sediment to form the level plains of the western interior, over extensive portions of which the highest floods of to-day never reach, and wells or artificial reservoirs have now to be made to supply water for stock. We all know of the rich pasturage that appears in this country in a favourable season. I have recently had the pleasure of travelling over the "Stony Desert," where the gallant explorer Sturt was so long shut in by the drought. I found its stony character truly described; but the stones were almost hidden from view by the splendid growth of herbage after the late rains; the long grass waved as the wind passed over it, and the whole country was brilliant with wild

flowers. How luxuriant, then, must have been the vegetation in the Pleistocene period, when a great rainfall prevailed for thousands of years. Can we not at once realize how, under these favourable conditions, so many and gigantic animals existed throughout the country ; why crocodiles abounded in the Darling River country, near Brewarrina ; and also how both vegetation and animals gradually died out as the wet climate changed to its present arid condition—just as we now witness, in a small degree, the awful devastation of pasturage and of animal life over the same country when a season of drought comes on and lasts for only one or two years.

It has been said that Astronomy explains the principal cause of these remarkable periodical changes of climate ; and it is believed that our great rainfall period was contemporaneous with the glacial period which has left such marked evidences in the Northern Hemisphere ; during this period the Northern and Southern Hemispheres being alternately glaciated.

Its consideration is one of much importance in Natural History investigations, for without it the origin of the living fauna and flora, as well as of many of the physical features of Australia, cannot be rightly understood. The present animals and plants are the successors, direct descendants in some cases, of those which lived under more favourable conditions of existence during the Pleistocene period. This period, therefore, as I have already said, possesses much scientific interest, and from it are avenues open for research in Geology, Palæontology, Botany, Zoology, Physical Geography, Astronomy, etc., which should command the special attention of Members of this Society.

The phenomena of the Recent period are also of importance for scientific observation, such as the wasting of land surfaces, the widening and erosion of creeks and river channels, the wearing away of coast frontages, and other effects of atmospheric and marine denudation ; sand-drifts by wind, silting up of water courses and harbours, and other modes of transit and deposition of rock material ; the decomposition of rocks and the nature of

soils; the occurrence of corals, shells, and other organic remains;—results of observations upon these would, if recorded, not only enable this Society to diffuse information for the interpretation of phenomena observed in connection with the previous Geological periods, but they would be of practical value in reference to the beneficial occupation of the country by man.

It is only in the Recent deposits that human remains have been found in Australia; so that the advent of man upon this Continent does not appear to be of very ancient date. At Bodalla, a stone hatchet has been found at a depth of fourteen feet below the surface; and at Long Bay, near Coogee, Messrs. T. W. Edgeworth David, and Etheridge discovered a portion of an aboriginal skeleton three feet six inches below the present surface of the ground, and lying upon an old land surface. Two sharpened stones were found under the arms of this skeleton, and several bivalve shells, some of which had not been opened. It is believed to have been buried upon the old land surface, and that at least three feet of soil have since naturally accumulated over it; so that it is probably one of the oldest known human remains. Very little evidence as to the antiquity of man in Australia has yet been obtained; the subject is almost an entirely new one for inquiry, and attention should be given to it without delay, lest the old haunts of the natives should be destroyed by modern settlement.

The subject of Australian Palæontology presents quite as many points of interest to the student as does that of its Geology and other kindred subjects. I shall endeavour to show through a brief reference to the more important established facts how wide a field we have around us for original research in the attempt to fill up the gaps which exist in our "Fossil Record." In doing this I have been aided by my colleague, Mr. Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales.

The lowest fossiliferous bed yet recorded in Australia is the Parara Limestone of Yorke's Peninsular, South Australia, in which Mr. Otto Tepper has discovered trilobites, believed by Dr. H.

Woodward to have an Upper Cambrian facies. In Victoria, Professor McCoy has proved the existence, through the presence of graptolites, of an old fauna analagous to that of Europe and America, and comprised within the great division known to Murchison as the Lower Silurian. To speak more precisely, these fossils probably represent an horizon equivalent to the Llandiello. The same authority has also demonstrated the presence in the Southern Colony of rocks of Upper Silurian age, comprised within the sub-division known as the Wenlock and Ludlow series. In our own Country the Lower Silurian, as *fossil-bearing* rocks, are apparently absent, although they may be probably represented by others of a metamorphic character. On the other hand, the Upper Silurian is widely represented in New South Wales, more particularly in the neighbourhood of Yass, where there are certainly representatives of the Wenlock, or perhaps other divisions of that wonderful formation. In Western Australia and Queensland, rocks of Silurian age have not yet been satisfactorily proved, although it is possible that the gold-bearing series of North-West Australia and the Northern Territory may be of this period. Now, these detached "horizons" exemplify how much remains to be accomplished in proving the existence, or otherwise, of the intermediate groups, and the absolute relation borne by them to similar deposits in other parts of the World.

The Devonian strata of this Continent are even less known than the Silurian. McCoy seems to have satisfactorily established the existence of a Devonian fauna and flora in Gippsland. DeKoninck has to some extent shown the same for New South Wales, through the collections of the late Rev. W. B. Clarke. So far as published data go, Queensland possesses by far the best marked Devonian fauna. Through the surveys of my lamented friend, the late Richard Daintree, C.M.G., and more recently those of Mr. R. L. Jack, the limestones of Burdekin Downs have been well explored, and found to contain a very copious fauna probably representing the Middle Devonian of Europe and North America. The relation of these far widely separated centres of

Devonian life to one another, and their bearing on the correlation of the rocks containing them with those of distant countries opens even a wider field of enquiry than we found presented to us by the Silurian.

On approaching the Carboniferous we meet with a much more easily correlated group of organic remains, although many points in connection with their relation to similar groups abroad require elucidation. Both in New South Wales, Victoria, and Queensland, there is a well marked flora of Lower Carboniferous age, by some considered as Upper Devonian. This is found in the neighbourhood of Stroud in the first named Colony, characteristic of the Avon Sandstones in the second, and the Drummond Range and other localities in the last. All three have plants in common, but the precise relation of this flora to the higher marine Carboniferous beds is not at present apparent. The sequence in New South Wales appears to be the most satisfactory, and it is probably here that the question will be solved. The relation of the Upper and Lower Marine Series is a very close one, the fossils apparently having a mixed Carboniferous and Permian facies, and there is much to be said in favour of referring to these under the one general term of Permo-Carboniferous. The Upper and Lower Coal Measures, alternating with the two sets of marine beds, are peculiar from the absence of any portion of their fauna, and in fact by the general, although not absolute absence of animal remains. The flora of the New South Wales Coal Measures is of particular interest from the great preponderance of the genus *Glossopteris*, and in working out the life history of this plant, it becomes necessary to institute a close comparison with the coal-bearing rocks of South Africa and India. This has to a large extent been accomplished by Dr. Ottokar Feistmantel, but much still remains to be done. Without doubt, the greatest paleontological service which could be rendered to the Geology of New South Wales would be a complete elucidation of the relations of the various divisions of her Carboniferous System one to the other, and to those of other countries; the physical conditions under

which the beds were laid down ; and a limitation of the series in an upward direction, where merging into the succeeding Clarence and Hawkesbury-Wianamatta Series.

Marine Carboniferous beds are known to exist in Western Australia, but too little has yet been accomplished to show their relation to those of Eastern Australia.

The rocks known as the Hawkesbury-Wianamatta, including with them the Clarence Series, possesses a flora of a still stronger Mesozoic type than the Upper Coal Measures, but much yet remains to be done before any determinate views can be arrived at.

The remains of Labyrinthodonts are met with sparingly, and those of fish much more frequently—which seem to bear out the Triassic age assigned to these beds ; but the whole question is at present such an open one, that it may practically be described as new.

Much doubt at present hangs over the relations of the other Mesozoic deposits of Australia. In Queensland and Victoria are Mesozoic coal and plant-bearing strata of doubtful stratigraphical position. In the former Colony we have the Oakey Creek beds, near Cooktown ; those of the Burrum Coal-field, near Maryborough ; and the Ipswich Coal basin. In Victoria is the Bacchus Marsh Sandstone ; the Capes Patterson and Otway series, and the beds of the River Glenelg. All have more or less yielded fossils, and require to have their correct horizons indicated, in which Palæontology will play no mean part. The late Mr. Charles Moore endeavoured to show the existence of almost all the Mesozoic stratigraphical sub-divisions from the Lias upwards. A critical examination of his paper will show that the author was led away by his enthusiasm for the subject, and endeavoured to prove too much on too little data. There is reason to believe, however, that in Western Australia beds probably of Oolitic age do exist. But where they pass into, or what relation they bear to the immense formation occupying so large a part of Central and Eastern Queensland, and South Australia, and which even

occurs in the North-Western corner of our own Colony, is still an open question. This great geological area is generally assigned to the Cretaceous Period. Perhaps it would be better to provisionally term it Cretaceo-Jurassic, pending the investigations, which my very general remarks will show there is more than ample room for. Certain it is that Cretaceous rocks do occur throughout the area I have indicated, as evinced by the writings of McCoy, Etheridge, and other authors. In the meantime we may content ourselves by adopting the convenient general term of "Rolling Downs Formation," suggested by Mr. R. L. Jack for so very debatable a series of beds.

Turn which way we will, there is the same scope for enquiry in every branch of Australian Palæontology. Just as we noticed many undoubted well established horizons in the Palæozoic Series, so in the Tertiary we have cognizance, through the long and patient labours of Profs. McCoy and Tait, and the Rev. J. E. Tenison-Woods, of equally well marked sub-divisions, including the marine Oligocene beds of Hobson's Bay, and the Miocene and Pliocene series extending along the Southern Coast of the Continent from the Gippsland Lakes to and beyond the Great Australian Bight. To the student of Palæontology there are years of study before him, notwithstanding all that has been done in contemplating the relation of the fauna of such deposits to that of the present day, and their correlation with similar forms of life in other lands. In New South Wales and Victoria there is the vast field of enquiry connected with the Palæophytology of the Deep Auriferous and Stanniferous Leads—one hitherto only touched upon, comparatively speaking, by such eminent botanists as Von Mueller and Ettingshausen. The investigations of the former have shown the existence in the Pliocene Gold-drifts of a flora containing numerous extinct forms, some of which have living allies. Marine action must have assisted at times in the formation of these drifts, as evinced by the important discovery of fossils made in the Stawell (Vict.) drifts by Messrs. Bernhard Smith and Norman Taylor. This is a most important point, and

requires further investigation. The large number of still unworked drifts will doubtless yield abundant material for further study and comparison. Perhaps one of the most interesting results yet brought to light, by the study of the ancient life history of Australia, is Baron von Ettingshausen's conclusions respecting the Tertiary Flora, more particularly as elucidated by that of the Stanniferous Deep Leads of the Vegetable Creek District. He states—"There is no doubt that the Tertiary flora of Australia contains, besides the elements of the living flora, also elements of other floras extinct in Australia, but developed now in other parts of the Globe. We have found the same mixture of the elements of the floras in the Tertiary flora of Europe, of America, and of Asia."

In connection with the Post Tertiary Deposits, so many interesting problems present themselves that it is difficult to select them for consideration. There will, however, arise the question of the genesis of the huge extinct Marsupialia, the conditions under which they lived, and the causes of their extinction.

The exploration of our Ossiferous Caverns is but in its infancy, and by investigations carried on judiciously, and more so than in the past, we may hope to throw light upon some of the points raised.

Finally, we come to the advent of Man himself on this Continent, a subject which legitimately comes within the scope of palaeontological enquiry, and one, so far, totally neglected. Within the limits of Australian Geological history, there is probably no subject of such absorbing interest as the earliest history of a fast disappearing race. The solution of this question does not appear to lie in the cave deposits, but rather will be revealed by a careful and thorough examination of the "kitchen-middens" and raised-beaches of the coast, and old burial grounds of the interior.

I have thus briefly directed your attention to the different formations with a view of showing what a wide field lies before us

for geological and palaeontological investigation. And when we remember that in these formations there have been already opened practically inexhaustable stores of nearly all the minerals that are of economic value, should we not be inspired with that zeal for discovery which the exploration of a new country always creates? and is not this zeal increased at the foresight of the establishment of commercial industries which such discovery promotes, and upon which the prosperity of the colony depends? This is no visionary prospect. The late Rev. W. B. Clarke foretold the importance of his discovery of gold many years before Messrs. Hargreaves, Lister, and Tom, practically demonstrated, in 1851, the occurrence of the precious metal in quantity at Lewis Ponds—a discovery which then set alight that unextinguishable fire of enthusiasm in mining and commercial enterprise, which, with increasing vitality, is manifested again and again, and especially so at the present time, when the recent discoveries of silver are fascinating the minds of many. The assurance of our venerated geologist was founded upon a knowledge of the geological character of the country.

Sir Roderic Murchison also, from rock specimens sent from here to England, identified the existence of formations similar to the auriferous rocks of the Ural Mountains, and in 1844 urged the unemployed miners of Cornwall to emigrate to Australia to search for gold.

We all know how the marvellously rich discoveries of gold, amounting to £36,863,717, have since sustained those geological deductions; and the examinations made by the officers of the Geological Surveys of New South Wales and of the other colonies reveal the fact that though the more easily worked shallow alluvial deposits and deep leads have hitherto afforded the principal supplies of gold and are far from being exhausted, yet the auriferous formations with their dykes and reefs, from the denudation of which the alluvial gold has been chiefly derived, are of immense extent, (in this colony alone at least 70,000 square miles) and their

development is in its infancy and will be a lasting source of wealth : it would be well therefore in every way to promote it.

But in addition to gold, New South Wales possesses other rich mineral resources in her large deposits of coal, tin, silver and lead, copper, shale, iron, bismuth, antimony, and sundry minerals including diamonds. Coal stands at the head of our economic minerals, classed according to the value of their annual production. And we may justly give precedence to our immense coal resources, for they are of the greatest commercial and national importance, and in their development lies the success of many industries not only in New South Wales but in the other colonies. This is evident when we consider that of the annual production of coal about 39 per cent. was raised for consumption here, as much as 25 per cent. was exported to foreign ports, and 36 per cent. to intercolonial ports, Victoria alone taking 22 per cent. It has been estimated that the coal seams now worked, if drawn upon at double the present output will last for 2,500 years. What possibilities therefore of future industrial expansion have we not in the development of this great store of mineral wealth ; and as the stability and progress of commerce depend so largely upon the aid of science, do we not see the wide sphere of usefulness that the Royal Society will occupy in taking its proper share in the work of raising this country to the national position that Nature reveals it is destined to attain.

Time will not permit me to refer to other sections of work undertaken by the Society ; but in what I have already said it has been my desire to indicate the ever-widening sphere that lies around us for scientific investigation.

Science is the revealing of Truth in all its aspects. Whether that revelation be the knowledge of a simple mineral, or the great central orb of our planetary system ; the lowest form of vegetable or animal life, or of its highest manifestation in the human mind—a reasoning mind that can bring into subjection natural laws, while it perceives itself to be subject to a higher control—its one aim is Truth.

Truth seekers have many and divergent paths to follow, but a unity of purpose should lead them on. I say *should* lead, for at the present day there is too much disunity of action amongst Science-workers. This is fostered by many who in practice, though perhaps not in theory, deny to workers in certain branches of Science, such as Psychology, fellowship with those in the more material fields of Natural History. This discordancy let it be our constant object to discourage.

The name of Darwin has become a by-word with many who oppose the advance of Science; and we must confess that the same spirit has been retaliated on the part of men of Science.

In the history of Science Charles Darwin will ever stand prominent as one of the greatest apostles of Truth as it is in Nature, and of that principle of growth or evolution which the old Bible, more than any other book, affords illustration of and emphatically teaches.

Darwin in his devotion to Natural History alone, may be likened to a mason engaged in the erection of a portion of a great building, who performed the finest of workmanship without knowing or caring to know the complete design of the Architect. He carried out a certain work, and it stands an imperishable monument of his fidelity and ability.

Darwin's teaching of evolution is in the highest degree exemplified in that greatest of modern facts—the progress of Civilization under the elevating influence of Christianity, aided by Science, Art, Literature and Philosophy, which it is the object of our Society to promote.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 2nd MAY, 1888.

ANNUAL GENERAL MEETING.

C. S. WILKINSON, F.G.S., President. in the Chair.

About forty members were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st March, 1888, was presented by the Hon. Treasurer and adopted :—

GENERAL ACCOUNT.

RECEIPTS.				£	s.	d.	£	s.	d.
Subscriptions	{ One Guinea	...	...	256	4	0	645	15	0
	{ Two Guineas	...	...	344	8	0			
	{ Arrears	...	...	45	8	0			
Entrance and Composition Fees				...	...	...	60	18	0
Parliamentary Grant on Subscriptions				...	...	...	...	...	...
and Entrance Fees received during				...	...	...	...	...	...
1887				...	...	...	434	8	0
Rent of Hall				...	...	...	95	3	6
Sundries				...	...	...	12	6	5
Total Receipts				...	...	...	£1,238	5	11
Balance on 1st April, 1887				...	...	...	20	17	0
				...	...	...	£1,259	2	11
PAYMENTS.				£	s.	d.	£	s.	d.
Advertisements				...	...	...	85	0	0
Assistant Secretary				...	...	...	250	0	0
Books and Periodicals				...	...	...	167	19	9
Bookbinding				...	...	...	43	3	5
Freight Charges, Packing, &c.				...	...	...	14	11	8
Furniture and Effects				...	...	...	1	11	6
Gas				...	...	...	17	8	9
Housekeeper				...	...	...	10	0	0
Insurance				...	...	...	10	16	7
Prize Essay Award				...	...	...	25	0	0
Postage and Duty Stamps				...	...	...	45	10	0
Petty Cash Expenses				...	...	...	16	10	7
Carried forward				...	...	...	637	12	3

PAYMENTS—continued.							£	s.	d.
Brought forward		...	...	...	...	...	637	12	3
Printing	...	...	...	...	...	...	42	11	2
Printing and Publishing Journal		...	...	...	...	...	210	1	8
Rates	...	...	...	...	...	...	27	9	0
Refreshments, &c., at Meetings		...	...	...	...	...	11	4	0
Repairs	...	...	...	...	...	...	46	5	11
Stationery	...	...	...	...	...	...	3	15	5
Sundries	...	...	...	...	...	...	28	2	0
Total Payments		...	...	...	...	...	£1,007	1	5
Transfer to Building and Investment Fund		...	...	...	...	...	192	8	0
Balance on 31st March, 1888—									
{ Union Bank		...	...	£49	18	6 }	59	18	6
{ Cash in hand		...	...	10	0	0 }			
							£1,259	2	11

AUDITED—H. O. WALKER.

HARRIE WOOD.

ROBERT HUNT, *Honorary Treasurer.*

W. H. WEBB, *Assistant Secretary.*

SYDNEY, 22nd April, 1888.

BUILDING AND INVESTMENT FUND.

RECEIPTS.							£	s.	d.
Donations	...	...	...	...	...	...	1	1	0
Parliamentary Grant on Balance of Donations received during 1886	...	...	...	...	...	...	7	7	0
Interest on Fixed Deposit...	...	...	...	...	...	...	8	15	0
Total Receipts	...	...	...	...	...	...	17	3	0
Transfer from General Account	...	...	...	...	...	...	192	3	0
Balance on 1st April, 1887	...	...	...	...	...	...	175	5	1
							£384	11	1

PAYMENTS.							£	s.	d.
Fixed Deposit in Union Bank	...	...	...	...	...	...	384	11	1
							£384	11	1

AUDITED—H. O. WALKER.

HARRIE WOOD.

ROBERT HUNT, *Honorary Treasurer.*

W. H. WEBB, *Assistant Secretary.*

SYDNEY, 22nd April, 1888.

CLARKE MEMORIAL FUND.

							£	s.	d.
Amount of Fund on 1st April, 1887	...	...	...	...	...	...	266	10	9
Interest accrued to 31st March, 1888	...	...	...	...	...	...	10	11	0
							£267	1	9

	£	s.	d.
Fixed Deposit in Union Bank	236	17	0
Balance due from Oriental Bank...	30	4	9
	<u>£267</u>	<u>1</u>	<u>9</u>

AUDITED—H. O. WALKER. ROBERT HUNT, *Honorary Treasurer.*
 HARRIE WOOD. W. H. WEBB, *Assistant Secretary.*
 SYDNEY, 22nd April, 1888.

SMITH MEMORIAL FUND.

	£	s.	d.
Amount of Fund on 1st April, 1887	112	6	6
Interest on Fixed Deposit	6	14	4
	<u>£119</u>	<u>0</u>	<u>10</u>

	£	s.	d.
Amount remitted for Painting	110	0	0
Balance in Union Bank	9	0	10
	<u>£119</u>	<u>0</u>	<u>10</u>

AUDITED—H. O. WALKER. ROBERT HUNT, *Honorary Treasurer.*
 HARRIE WOOD. W. H. WEBB, *Assistant Secretary.*
 SYDNEY, 22nd April, 1888.

Messrs. J. T. Wilshire and P. N. Trebeck were elected Scrutineers for the election of officers and members of Council.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year :—

Honorary President:

HIS EXCELLENCY THE RIGHT HON. LORD CARRINGTON, G.C.M.G.

President:

SIR ALFRED ROBERTS.

Vice-Presidents:

H. C. RUSSELL, B.A., F.R.S. | C. S. WILKINSON, F.G.S., F.L.S.

Hon. Treasurer:

ROBERT HUNT, F.G.S., &c.

Hon. Secretaries:

PROF. LIVERSIDGE, M.A., F.R.S., &c. | F. B. KYNGDON.

Members of Council:

W. A. DIXON, F.C.S., &c.	P. R. PEDLEY.
A. LEIBIUS, PH. D., M.A., F.C.S.	PROF. THRELFALL, M.A. (Cantab.)
CHARLES MOORE, F.L.S.	PROF. WARREN, M.I.C.E.

The following gentlemen were duly elected ordinary members of the Society :—

O'Neil, G. Lamb, M.B., C.M., *Edin.*; Sydney.

Smith, Charles Atkinson, F.C.S., F.I.C.; Sydney.

Thring, Edward T., F.R.C.S. *Eng.*, L.R.C.P. *Lond.*; Petersham.

The certificates of two new candidates were read for the second time, and of three for the first time.

The names of the Committee-men of the different Sections were announced, viz. :—

MEDICAL SECTION. { Chairman ... Dr. Knaggs.
Secretaries.. Dr. MacCormick and Dr. Jenkins.
Committee... Dr. W. Chisholm, Dr. Crago, Dr. E. Fairfax Ross, Dr. Hankins, Dr. W. H. Goode, Dr. P. Sydney Jones.

Meetings held on the Third Friday in each month, at 8.15 p.m.

MICROSCOPICAL SECTION. { Chairman ... F. B. Kyngdon.
Secretary ... Percy J. Edmunds.
Committee... H. G. A. Wright, M.B.C.S.E., H. O. Walker, S. MacDonnell, and Dr. Morris.

Meetings held on the Second Monday in each month at 8 p.m.

SANITARY SECTION. { Chairman ... J. Trevor Jones, C.E.
Secretary ... Reuter E. Roth, M.B.C.S.E.
Committee... R. Hunt, Dr. W. Chisholm, E. E. Sager, W. A. Dixon, F.C.S., Dr. Ashburton Thompson, J. B. Henson, C.E.

Meetings held on the Second Tuesday in the month at 8.15 p.m.

The following letter was read from the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.:—

533 Elizabeth Street, Sydney,
5th March, 1888.

To C. S. Wilkinson, Esq., F.L.S., F.G.S.,

President of the Royal Society of New South Wales.

My dear Sir,

I have the honour to acknowledge the receipt of your letter and medal, conveying to me the Society's award of the Clarke Medal for this year. In thanking the Society for this distinguished mark of their estimation, I feel myself quite inadequate to express my sense of the honour thus conferred upon me.

If any services that I have rendered to Science were deserving of a reward this more than amply satisfies my greatest anticipations, and I trust it will be a new stimulus to exertion.

I regret exceeding that my present state of health prevents me from taking a more active part in the labours of the Society, but I have every hope and confidence that I shall yet be able to labour for its interests, and I shall ever consider myself honoured by being associated even in the humblest way with its labours.

Pray convey my warmest thanks to the members of the Council, and believe me, Mr. President

Yours very faithfully,

J. E. TENISON-WOODS.

Mr. C. S. Wilkinson, F.G.S., F.L.S., President, then read his address.

A vote of thanks was passed to the retiring President, and Sir Alfred Roberts was installed as President for the ensuing year.

EXHIBIT.

Mr. Lawrence Hargrave exhibited a compressed air engine for driving a flying-machine, describing it as follows:—the cylinder is $1\frac{1}{2}$ inches diameter and the stroke is 2 inches: the engine weighs 2 lbs 7 oz. The receiver for the compressed air is .21 cubic feet capacity, made of $\frac{1}{4}$ inch steel, single rivetted, and brazed: the bursting pressure is about 900 lbs per square inch: the working pressure will be 500 lbs per square inch, and the reduced pressure 100 lbs per square inch; and there will be 9,200 foot-pounds available for work: this power will have to be expended in from half to three-quarters of a minute. The charged receiver weighs 6 lbs 12 ozs. A small Richard's indicator has been made for adjusting the piston valve. The wood and paper work will weigh about 2 lbs. The machine is intended for a flight of 200 yards. As it will be some time before the whole of the apparatus is in a condition to offer to this Society in the form of a paper, anyone wishing to assist in the development of artificial flight may have a tracing of the working drawing now, and make sketches of the deviations: and from these a double sized machine could be made introducing more steel and less brass, and using triple expansion with a receiver pressure of 1,500 lbs, and a factor of safety of 2. I am indebted to Mr. James Richard Thomson for much information that has been of great assistance to me.

The following donations received since the last meeting were laid upon the table:—

LIST OF DONATIONS RECEIVED SINCE DECEMBER 7TH, 1887.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

- ABERDEEN**—University. Catalogue of the General Library, Vols. i. and ii., and Supplement 1873—87. Catalogue of the Library, Vol. iii., Law Medicine, 1874. *The University.*
- ADELAIDE**—Forest Flora of South Australia, Part 8. *Government Printer, S.A.*
 Royal Society, Transactions of the Intercolonial Medical Congress of Australasia, First Session held in Adelaide, S.A., August to September, 1887. *The Society.*
 University. The Adelaide University Calendar for the Academical Year 1888. *The University.*
- AGRAM**—Société Archéologique. Vjestnik hrvatskoga Arheologiokoga Druztva, Godina ix., Br. 4, 1887; x., Br. 1, 1888. *The Society.*
- AMSTERDAM**—Revue Coloniale Internationale, Tome v., Nos. 5 and 6, November and December, 1887. *The Editors.*

- AUCKLAND**—Auckland Institute, and Museum. Report for 1887—88. *The Institute.*
- ANNAPOLIS (MD.)** United States Naval Academy. Annual Register, Thirty-eighth Academic Year 1887—88. *The Academy.*
- BALLAARAT**—The Ballaarat School of Mines, Industries and Science. (In the University of Melbourne.) Annual Report for 1887. *The School of Mines.*
- BALTIMORE**—Johns Hopkins University. American Chemical Journal, Vol. ix., Nos. 1 and 2, 1887. American Journal of Mathematics, Vol. ix., Nos. 2 and 4, 1887. American Journal of Philology, Vol. vii., Part 4, 1886; Vol. viii., Part 1, 1887. Historical and Political Science, Fifth Series, Nos. iv.—vii., 1887. University Circulars, Vol. vi., Nos. 66 and 57, 1887. *The University.*
- BERGEN**—Museum. Aarsberetning for 1886. *The Museum.*
- BERLIN**—Königlich Preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 40—52, 22nd October to 17th December, 1885; Nos. 19—39, 14th April to 28th July, 1887. *The Academy.*
- Königl. Preuss. Meteorologisches Institut. Ergebnisse der Meteorologischen Beobachtungen im Jahre, 1886. *The Institute.*
- BERNE**—Société de Géographie de Berne. Jahresbericht, Vol. viii., 1885 to 1887. *The Society.*
- Schweiz Departement des Innern. Graphische Darstellung der Schweizerischen hydrometrischen Beobachtungen, Bl. i., ia., ib., ii., iia., iib., iii., iv., v., vi. *The Department.*
- BIRMINGHAM**—Birmingham and Midland Institute. Programme for Session 1887—88. Report of the Council for the year 1887. *The Institute.*
- Birmingham Philosophical Society. Proceedings, Vol. v., Part 2, Session 1886—87. *The Society.*
- BOLOGNA**—R. Accademia delle Scienze dell' Istituto di Bologna. Memorie, Serie iv., Tome vi., 1884, and vii., 1886. *The Academy.*
- BRAUNSCHWEIG**—Vereins für Naturwissenschaft. Jahresbericht, Vol. v., 1886 bis 1887. *The Society.*
- BRISBANE**—Acclimatisation Society of Queensland. Catalogue of Plants in the two Metropolitan Gardens, the Brisbane Botanic Garden and Bowen Park, by F. M. Bailey, F.L.S. List of Plants usually available for Distribution at the Acclimatisation Society's Gardens, Bowen Park, Brisbane. „
- BRISTOL**—Bristol Naturalists' Society. Proceedings, New Series, Vol. v., Part 2, 1886—7. Annual Report for the year ending 30th April, 1887. „
- CALCUTTA**—Asiatic Society of Bengal. Journal, Vol. liv., Part ii., No. 4, 1885; Vol. lv., Part ii., No. 5, 1886; Vol. lvi., Part ii., No. 1, 1887. Proceedings, Nos. 6, 7, 8, June, July, August, 1887. „

D—May 2, 1888.

CALCUTTA—*Continued.*

Geological Survey of India. A Manual of the Geology of India, Part iv. Mineralogy, 1887. Memoirs of the Geological Survey of India, Vol. xxiv., Part 1, 1887. Memoirs (Paleontologia Indica), Series x., Vol. iv., Part 3, 1887. Records, Vol. xx., Part 4, 1887.

The Director.

CAMBRIDGE—Cambridge Philosophical Society. Proceedings, Vol. vi., Parts 2 and 3, 1887.

The Society.

CAMBRIDGE (MASS.)—Museum of Comparative Zoölogy at Harvard College. Annual Report of the Curator for 1886-87. Bulletin, Vol. xiii., Nos. 5 and 6, 1887. Memoirs, Vol. xvi., Nos. 1 and 2, 1887.

The Museum.

Psyche, Vol. v., Nos. 141-142, Jan.-Feb., 1888.

The Editor.

CHARLOTTESVILLE, VA. University of Virginia. Annals of Mathematics, Vol. iii., Nos. 4 and 5, 1887.

The University.

CINCINNATI—Cincinnati Society of Natural History. Journal, Vol. x., No. 4, Jan., 1888.

The Society.

COPENHAGEN—Société Royale des Antiquaires du Nord. Mémoires, Nouvelle Série, 1887. Tillæg til Aarbøger for nordisk Oldkyndighed og Historie Aargang, 1886.

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CORDOBA—Academia Nacional de Ciencias.—Actas, Tomo v., Entrega Tercera, 1886.

The Academy.

DRESDEN—Königlich Sächsische Statistische Bureau. Statistische Mittheilungen über die Grundstücken-Zusammenlegungen im Königreiche Sachsen vom Jahre, 1833, bis zum 30 Juni, 1887. [Supplement heft zur Zeitschrift, xxxiii., Jahr., 1887.

The Bureau.

DUBLIN—Royal Geological Society of Ireland. Journal, Vol. xviii., Part 2, New Series, Vol. viii., Part 2, 1886-1887.

The Society.

EDINBURGH—Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. iii., No. 12, 1887; Vol. iv., Nos. 1, 2, 3, 1888.

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FLORENCE—Società Africana d' Italia (Sezione Fiorentina). Bullettino, Vol. iii., Fasc. 7, 1887, Fasc. 8, 1888.

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Società Entomologica Italiana. Bullettino, Vol. xix., Trimestri 3 & 4, 1887.

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GEELONG—Gordon Technical College. Constitution and Progress Report, 1887.

The College.

GÖTTINGEN—Königl. Gesellschaft der Wissenschaften und der Georg-Augusta-Universität. Nachrichten, Nos. 1-20, 1886.

The Society.

HALIFAX—Nova Scotian Institute of Natural Science. Proceedings and Transactions, Vol vi., Part 3, 1884-5.

The Institute.

HAMBURG—Deutsche Meteorologische Gesellschaft. Meteorologische Zeitschrift, Heft 11 and 12, 1887; Heft 1, 2 and 3, 1888.

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HAMBURG—Continued.

- Deutsche Seewarte. Aus dem Archiv der Deutschen Seewarte, vii., Jahrgang, 1884. Deutsche Ueberseeische Meteorologische Beobachtungen, Heft 1, 1883-87. Meteorologische Beobachtungen in Deutschland, für 1878-1885, Jahrgang, i.-viii., incl. Resultate Meteorologischer Beobachtungen von Deutschen und Holländischen Schiffen für Eingradfelder des Nordatlantischen Ozeans, Nos. i.-vii., 1880-1887. *The Observatory.*
- Geographische Gesellschaft in Hamburg. Mittheilungen, Heft iii., 1885-86. *The Society.*
- Naturhistorisches Museum zu Hamburg, Bericht für das Jahr., 1886. *The Museum.*
- HARLEM**—Société Hollandaise des Sciences. Archives des Sciences Exactes et Naturelles, Tome xxii., Liv. 2 and 3, 1887. *The Society.*
- HEIDELBERG**—Naturhistorisch Medicinischer Verein. Verhandlungen, Neue Folge, Band iv., Heft 1, 1887. „
- HOBART**—Royal Society of Tasmania. Abstract of Proceedings, 21st Nov. 1887. „
- IOWA CITY**—Iowa Weather Service. Report for the year 1886. *The Director.*
- JENA**—Medicinisch Naturwissenschaftliche Gesellschaft. Jenaische Zeitschrift, Band xxi., N.F. Band xiv., Heft 1 to 4, 1887. *The Society.*
- KIEFF**—Société des Naturalistes de Kieff. Mémoires, Supplément au Tome viii., 1887. „
- LEIPZIG**—Königlich Sächsische Gesellschaft der Wissenschaften. Berichte über die Verhandlungen, Mathematisch-Physische Classe, Nos. i., ii., 1887. „
- Vereins für Erdkunde. Mittheilungen, Heft 1, 2 and 3, 1886. „
- LIEGE**—Société Royale des Sciences. Mémoires, Série 2, Tome xiv., 1888. „
- LONDON**—Geological Society. List of the Geological Society of London, Nov. 1, 1887. Quarterly Journal, Vol. xliii., Part 4, No. 172, Nov. 1, 1887; Vol. xliv., Part 1, No. 173, Feb. 1, 1888. „
- Institution of Naval Architects. Transactions, Vol. xxviii., 1887. *The Institution.*
- Iron and Steel Institute. Journal, No. 2, 1887. „
- Linnean Society. Journal—Botany, Vol. xxiii., Nos. 152-154, 1887; Vol. xxiv., Nos. 160, 161, 1887. Zoology, Vol. xx., No. 118, 1887; Vol. xxi., No. 130, 1887; Vol. xxii., Nos. 136-138, 1887-8. List of the Linnean Society of London, Session 1887-1888, Dec., 1887. *The Society.*

LONDON—Continued.

- Meteorological Office. Hourly Readings, Part iv., Oct.-Dec., 1884, Official No. 70; Part i., Jan.-Mar., 1885, Official No. 74. Monthly Weather Report, December, 1886, Official No. 68. Quarterly Weather Report, Part iv., Oct.-Dec., 1878, Official No. 55; Parts i. and ii., Jan.-June, 1879, Official No. 49. Weekly Weather Report, Vol. iv., Nos. 12-45, 28th Mar.-14th Nov., 1887. Quarterly Summary of Ditto, Vol. iv., Appendix 1, 1st, 2nd, and 3rd Quarters. *The Meteorological Office.*
- Pharmaceutical Society of Great Britain. Calendar, 1888. Journal and Transactions, Vol. xviii. (Third Series), Parts 208-210, Oct.-Dec., 1887; Part 211, Jan., 1888. *The Society.*
- Quekett Microscopical Club. Journal, Ser. ii., Vol. iii., No. 20, Dec., 1887. *The Club.*
- Royal Asiatic Society of Great Britain and Ireland. Journal, New Series, Vol. xix., Part 4, 1887; Vol. xx., Part 1, 1888. *The Society.*
- Royal Astronomical Society. Monthly Notices, Vol. xlviii., Nos. 1, 2, 3, 1887-8. "
- Royal Geographical Society. Proceedings, New Monthly Series, Vol. ix., No. 12, 1887; Vol. x., Nos. 1 & 2, 1888. "
- Royal Historical Society. England and Napoleon in 1803. Edited by Oscar Browning, M.A., 1887. The Teaching of History in Schools, by Oscar Browning, M.A., 1887. "
- Royal Institution of Great Britain. List of the Members, 1887. Proceedings, Vol. xii., Part 1, No. 81, 1887. *The Institution.*
- Royal Meteorological Society. Quarterly Journal, Vol. xiii., No. 63, July, 1887. The Meteorological Record, Vol. vii., No. 26, 1887. *The Society.*
- Royal Microscopical Society. Journal, Part 6a, No. 61, Dec., 1887; Part 1, No. 62, Feb., 1888. List of Fellows, 1888. "
- Royal Society. Proceedings, Vol. xl., No. 245. "
- Royal United Service Institution. Journal, Vol. xxxi., Nos. 141 and 142. Index of the Lectures and Papers contained in Vols. xxi.-xxx. List of Members to 1st January, 1888. A Brief History of the Royal United Service Institution, by Captain Boughiey Burgess, 1887. *The Institution.*
- Zoological Society of London. Proceedings, Part iii., 1887. *The Society.*
- MANCHESTER—Geological Society. Transactions, Vol. xix., Parts i.-x., Session 1886-87. "
- MARBURG—University. Seventy-six (76) Inaugural Dissertations, 1886-87. *The University.*

- MELBOURNE**—Field Naturalists' Club of Victoria. *The Victorian Naturalist*, Vol. iv., Nos. 8-12, 1887-8. *The Club.*
- Government Botanist. *Iconography of Australian Species of Acacia and Cognate Genera*, by Baron F. von Mueller, K.C.M.G., M. & Ph. D., F.R.S., Decade v., vi., vii., viii., 1887. *The Govt. Botanist.*
- Government Statist. *Victorian Year Book for 1886-7.* *The Govt. Statist.*
- Mining Department. *The Gold-Fields of Victoria. Reports of the Mining Registrars for the Quarter ended 31st December, 1887.* *The Secretary for Mines.*
- Public Library, Museums and National Gallery of Victoria, Report of the Trustees for 1886. *Natural History of Victoria. Prodromus of the Zoology of Victoria*, by Frederick McCoy, C.M.G., M. A., Sc. D., Cantab., F.R.S., Decade xv., 1887. *The Director of the Museum.*
- MEXICO**—Sociedad Científica "Antonio Alzate." *Memorias*, Tome i., Cuaderno num 4 & 5, 1887. *The Society.*
- MINNEAPOLIS**—Minnesota Academy of Natural Sciences. *Bulletin*, 1875, 1878 and 1879, Vol. ii., No. 1, 1880. *Constitution and By-Laws*, with Address of President, List of Officers and Committees for 1873. *The Academy.*
- MODENA**—Regia Accademia di Scienze, Lettere ed Arti in Modena. *Memorie*, Serie i., Tome xx., Parte iii., 1882; Serie ii., Tome iv., 1886. „
- MONTREAL**—Natural History Society. *The Canadian Record of Science*, Vol. iii., No. 1, 1888. *The Society.*
- MOSCOW**—Société Impériale des Naturalistes. *Bulletin*, Nouvelle serie, Tome i., 1897. *Beilage*, Nouvelle serie, Tome i., 1887. „
- MULHOUSE**—Société Industrielle. *Bulletin de Septembre-December, 1887.* „
- MUNCHEN**—K. B. Akademie der Wissenschaften. *Abhandlungen der Mathematisch-Physikalischen Classe*, Band xv., Abth. 2 & 3, 1885-6; Band xvi., Abth. 1, 1887. *Sitzungsberichte Mathematisch-Physikalischen Classe*, Heft ii.-iv., 1884; Heft i.-iv., 1885; Heft i.-iii., 1886. *Inhaltsverzeichniss der Sitzungsberichte*, Jahrgang, 1871-1895. *Gedächtnissrede auf Carl Theodor v. Siebold*; von Richard Hertwig, 1886; *Gedächtnissrede auf Joseph von Fraunhofer*; von Carl Max v. Bauernfeind, 1887. *The Academy.*
- NAPLES**—Società Africana d'Italia. *Bollettino*, Anno vi., Fasc. 9-12, 1887; Anno vii., Fasc. 1-2, 1888. *The Society.*
- Società Reale di Napoli. *Rendiconto dell' Accademia delle Scienze Fisiche e matematiche*, Anno xxv., Fasc. 4-12, 1886. *The Academy.*
- Stazione Zoologica. *Mittheilungen*, Band vii., Heft 3 & 4, 1887. *The Station.*

- NEWCASTLE-UPON-TYNE—North of England Institute of Mining and Mechanical Engineers. Transactions, Vol. xxxvi., Part iv.; Vol. xxxvii., Part i., 1887. *The Institute.*
- NEW YORK—American Chemical Society. Journal, Vol. ix., Nos. 5, 6, 7 and 9, 1887. *The Society.*
- American Geographical Society. Bulletin, Vol. xix., Nos. 3 and 4, 1887. *"*
- Journal of Comparative Medicine and Surgery. Vol. ix., No. 1, 1888. *The Editor.*
- Science. Vol. x., Nos. 246-256, 1887; Vol. xi., Nos. 257-265, 1888. *"*
- New York Academy of Sciences. Annals, Vol. iv., Nos. 1 and 2, 1887. *The Academy.*
- New York Microscopical Society. Journal, Vol. iii., No. 4, 1887; Vol. iv., No. 1, 1888. *The Society.*
- School of Mines, Columbia College. School of Mines Quarterly, Vol. ix., Nos. 1 and 2, 1887-8. *The School of Mines.*
- OTTAWA—Geological and Natural History Survey of Canada. Catalogue of Canadian Plants, Part iii., *Apetalæ*, by John Macoun, M.A., F.L.S. *The Director.*
- OXFORD—Radcliffe Library. Catalogue of Transactions of Societies, Periodicals and Memoirs, Fourth Edition, 1887.
- Radcliffe Observatory. Results of Astronomical and Meteorological Observations in 1884, Vol. xlii. *The Radcliffe Trustees.*
- PARIS—Académie des Sciences de l'Institut de France. Comptes Rendus, Tome cv., No. 10 and Nos. 14 to 26, 1887. *The Academy.*
- Société d'Anthropologie de Paris. Bulletins, Série iii., Tome x., Fasc. 3, 1887. *The Society.*
- Société de Biologie. Comptes Rendus Hebdomadaires, Série 8, Tome iv., Nos. 33 to 42, 1887; Tome v., Nos. 1 to 10, 1888. *"*
- Société de Géographie. Bulletin, Série 7, Tome viii., Trimestre 2, 3 & 4, 1887. Compte Rendu, Nos. 13 to 16, 1887; Nos. 1 to 3, 1888. *"*
- Société Entomologique de France. Bulletin, Nos. 13 to 24, 1887. *"*
- Société Géologique de France. Bulletin, Série 3, Tome xv., No. 6, 1887. *"*
- Société Française de Minéralogie. Bulletin, Tome x., Nos. 7, 8, 9, 1887; Tome xi., No. 1, 1888. *"*
- Société Française de Physique. Réunion, 2nd & 16th Dec., 1887, 6th & 20th Jan., 3rd & 17th Feb., 2nd & 16th Mar., 1888. Séances, Avril-Juillet, 1887. *"*
- Société Zoologique de France. Bulletin, Vol. xii., Parts 5 & 6, 1887; Vol. xiii., Part 1, 1888. *"*
- PHILADELPHIA—Academy of Natural Sciences. Proceedings, Part i., January-April, 1887. *The Academy.*
- American Philosophical Society. Proceedings, Vol. xxiv., No. 125, 1887. *The Society.*
- Franklin Institute. Journal, Vol. cxxv., Nos. 745, 746, 747, 1888. *The Institute.*

- PORT LOUIS**—Royal Alfred Observatory. Annual Report of the Director for the year 1886. Mauritius, Meteorological Results for 1886. *The Observatory.*
- ROME**—Accademia Pontificia de Nuovi Lincei. Atti, Anno xxxvii., Sessione 6a-8a, 1884; Anno xxxviii., Sessione 1a-4a, 1884-5; Anno xl., Sessione 7a-8a, 1887; Anno xli., Sessione 1a-3a, 1887-8. *The Academy.*
- Ministero dei Lavori Pubblici. Giornale del Genio Civile, Serie 5, Vol i., Nos. 9-12, 1887; Vol. ii., Fascicolo 1, 1888. *The Minister of Public Instruction, Rome.*
- R. Comitato Geologico d'Italia. Bollettino, Nos. 7 to 12, 1887. *The Committee.*
- Società Geografica Italiana. Bollettino, Serie 2, Vol. xii., Fasc. 10-12, 1887; Serie 3, Vol. i., Fasc. 1 & 2, 1888. *The Society.*
- RIO DE JANEIRO**—Imperial Observatory. Revista do Observatorio, Anno iii., No. 1, Jan., 1888. *The Observatory.*
- SAINT ETIENNE**—Société de l'Industrie Minérale. Bulletin, Série 2, Tome xv., Liv. 3 & 4, 1886, and Atlas; Série 3, Tome i., Liv. 3, 1887, and Atlas. Table Générale des Matières, Série 2, Tome i.-xv., 1871-86. Comptes Rendus Mensuels, Nos. 14, 15, 16, Oct., Nov., Dec., 1887, and Jan., 1888. *The Society.*
- ST. PETERSBURGH**—Académie Impériale des Sciences. Bulletin, Tome xxxi., No. 4, 1887. *The Academy.*
- Comité Géologique—Institut des Mines. Bulletins, Tome vi., Nos. 8-10, and Supplément. Mémoires, Vol. ii., Nos. 4 & 5, Vol. iii., No. 3. *The Committee.*
- SALEM**—Essex Institute. Bulletin, Vol. xviii., Nos. 1-12, 1886. Historical Collections, Nos. 1-12, 1886. *The Institute.*
- SAN FRANCISCO**—California Academy of Sciences. Bulletin, Vol. ii., Nos. 6 & 7, 1887. *The Academy.*
- SIENA**—Regia Accademia dei Fisiocritici. Atti, Serie 3, Vol. iv., Fasc. 1-4, 1885-7. „
- SINGAPORE**—Straits Branch of the Royal Asiatic Society. Journal, No. 18, December, 1886. *The Society.*
- SYDNEY**—Australian Museum. Descriptive Catalogue of the Medusæ of the Australian Seas, by E. von Lendenfeld, Ph.D., 1887. History and Description of the Skeleton of a New Sperm Whale lately set up in the Australian Museum, by W. S. Wall, Curator, 1851; reprinted by order of the Trustees, 1887. *The Trustees.*
- Free Public Library. Report from Trustees for 1887-8. „
- Linnean Society of New South Wales. Proceedings, Second Series, Vol. ii., Part 4, 1887. *The Society.*
- Mining Department. Royal Commission—Conservation of Water—Third and Final Report of the Commissioners. *The Department.*

SYDNEY—*Continued.*

Royal Geographical Society, N. S. W. Branch. Proceedings of the Geographical Society of Australasia, New South Wales and Victorian Branches, Vol. i., 1st Session, 1883-4; Vol. ii., 2nd Session, 1884. Proceedings of the South Australian Branch, Vol. i., 1st Session, 1885-6. Special Record of the Proceedings of the Geographical Society of Australasia in fitting out and starting the Exploratory Expedition to New Guinea, July, 1885. Annual Addresses to the N. S. W. Branch, 1884-5 and 1885-6, by Sir Edward Strickland, K. C. B., F. R. G. S. New Constitution of the N. S. W. Branch, adopted 17th June, 1886.

The Society.

STUTTGART—Königliches Statistisches Landesamt. Württembergische Jahrbücher für Statistik und Landeskunde, Jahrgang, 1886, i. Band, 1 Hälfte; 1 Hälfte, 1 Heft & 3 Heft; ii. Band, 2 Hälfte.

The Bureau.

TOKIO—Seismological Society of Japan. Transactions, Vol. xi., 1887.

The Society.

TORONTO—Canadian Institute. Proceedings, Third Series, Vol. v., Fasc. 1, 1887.

The Institute.

TOULOUSE—Académie des Sciences, Inscriptions et Belles-Lettres. Mémoires, Série 8, Tome ix., 1887.

The Academy.

TRIESTE—Società Adriatica di Scienze Naturali. Bollettino, Vol. x., 1887.

The Society.

VENICE—Reale Istituto Veneto di Scienze, Lettere ed Arti. Atti, Serie 6, Tomo iii., Dispensa 10, 1884-5; Tomo iv., Dispensa 1-10 and Appendice, 1885-6; Tomo v., Dispensa 1, 1886-7.

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FOREST DESTRUCTION IN NEW SOUTH WALES AND
ITS EFFECTS ON THE FLOW OF WATER IN WATER-
COURSES AND ON THE RAINFALL.

By W. E. ABBOTT, Wingen.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

IN July, 1880, an essay which I wrote on "Ring-barking and its Effects," was read before this Society, and will be found in the Journal for that year. My object now is to lay before the members of the Royal Society, and place on record for future use, the results of observations and experiments which I have made on the same land, and on land adjoining that of which I then wrote. In my former essay I showed what had been the effect during a period of ten years of destroying the natural forest growth on some land of my own in the watershed of the Upper Hunter River, and what had been the general effect of ring-barking in that part of New South Wales for a period of about twenty years. The land of which I wrote is situated about twelve miles south-east of Murrurundi, on the Page River, a small tributary of the Hunter, has been in the possession of my family for more than forty years, and has been under my personal observation since I was old enough to observe anything. Writing in 1880, I showed that from 1847 to 1870 all the small creeks—and they are very numerous on this estate—had been dry water-courses never containing any water except for a short time after rain had fallen, and never running permanently throughout the summer no matter how favourable the season might be. In 1869, '70, and '71, a considerable portion of the land was ring-barked for the purpose of sweetening and improving the grass, but without any idea of what the effect might be on the flow of water in the creeks or water-courses or on the rainfall. At that time, as now, many of the wise men of New South Wales told us that the effect of destroying the forest growth would be to dry up the springs and rivers, and reduce the rainfall of the country. We were told that this had been the invariable result of forest destruction in Europe and in America, and must be the inevitable effect of such action here. We were urged to conserve the forests already in existence, and plant the great western plains of New South Wales with trees for the purpose of increasing the annual rainfall and the natural water supply. A late President of this Society

and a very eminent scientist, perhaps the most eminent in his own line that has yet appeared in Australia, was among the chief exponents of these views. It was then, and seems now to be generally accepted that it is the trees that produce the rain, and not the rain that produces the trees, and yet it seems to me that a very little thought will show the converse of this to be true. Rain may fall and does fall in the absence of forests, but it would be somewhat difficult for the forests to grow unless the rain fell first.

The results of forest destruction at Glengarry, on the Page River, were very remarkable, and similar results have followed in a greater or less degree in all cases that have come within my knowledge in the watershed of the Hunter River.

All the dry water-courses or creeks that were of any size in the ring-barked country became permanently flowing streams, and even in the small gullies less than half a mile in length springs broke out which are fairly permanent in most seasons. So that a country which from 1847 to 1870 was without any water except that contained in the Page River on the frontage, after having the forest destroyed became so watered throughout its whole extent, that one cannot go in any direction for more than half a mile without coming across running water.

And these springs and permanently flowing rivulets that were produced on Glengarry by the destruction of the forests about the year 1870 have remained permanent ever since, notwithstanding the severe and very protracted droughts through which we have passed in the last eighteen years. Of course they have been affected by the droughts, and the quantity of water in them very much reduced as has been the case with all sources of water supply in the Colony; but even in the most severe drought, which ended here in March, 1886, the supply of water in these rivulets and springs was ample for all purposes. The drought which ended here in the beginning of 1886 was, as shown by the rainfall records of the Government Observatory, one of the most severe experienced since the Settlement of the Colony, or at any rate since records have been kept, and the chief characteristic of this drought was the unusually long run of dry years in which the rainfall at almost all the recording stations throughout the Colony was below the average for each place.

In this part of the country there has not been any rainfall record kept farther back than 1870, and my own record only goes back to 1876; but there is on one of the mountains on Glengarry what may be regarded as a natural drought-gage. Very nearly on the top of the Lagoon Mountain, there is a lagoon or small lake at an elevation of over 3,000 feet above sea level, about 70 yards in length and of considerable depth. This lagoon has a

very small drainage area and was dry some time between 1848 and 1851, and never dried up again until the end of 1885. The whole of the country on the Lagoon Mountain remains in the same state now as in 1848 and previous years, or since it was first occupied. Here we have, I think, in the absence of any regularly kept records of rainfall, tolerably good proof that the drought which ended in the beginning of 1886 was at least as severe as anything experienced in the 40 years previous, and yet the rivulets and springs which we may say were artificially produced withstood its utmost severity.

My reason for placing these facts before you now, is to point out that the extremely remarkable results which followed forest destruction on Glengarry have not been of a temporary character, and have not been due to a coincident change in the seasons. When I wrote last, I placed before the members of this Society the results of some measurements of the permanent flow of water in three water-courses, which had begun to flow immediately the natural forest growth had been destroyed, and which previously as far back as any knowledge of them could be obtained had been dry water-courses. These measurements had been carefully made by myself, without regard to the flood water or freshets after rain, and gave the permanent flow of water averaging the three water-courses at about one-fortieth of the rainfall, and the measurements were made after a somewhat dry period. The whole of the water shown by these measurements was evidently additional water to that which would have been found in these water-courses before the forests were destroyed, though they did not show the whole of the additional water. From that time up to the present all these streams have continued to flow, and though they were much reduced in volume towards the end of 1885, they did not fail to give an ample supply of water for all purposes even after the Page River had stopped running in many places. In addition to this, over a large area of country which I have had ring-barked since 1880, precisely similar results to those first recorded have followed. It is generally held, I believe, that the surest test of scientific knowledge is that we shall be able to predict beforehand the results that will follow from certain combinations, forces put in operation, or work done.

Now, I think, with the mass of evidence ready to our hands, which has been accumulating in many parts of the Colony during the last thirty years, it is quite possible to predict with absolute certainty that in any given case where the character and general fall of the country is such that an extra supply of water in the ground would make its presence apparent in the water-courses, the effect of destroying the natural eucalyptus forests will be to cause a permanent increase of water in such water-courses, and

produce springs where there were none before. I have myself fenced in dry country, and afterwards produced permanently running streams by simply ring-barking the trees, and this I have been able to do because the country was in all respects similar to other country which had been operated on before.

Of course, the geological formation as well as the contour of the country has much to do with the question, whether deforestation in any given case will produce surface water or not. In many parts of the country where there are deep-lying beds of sand or gravel, an increased flow of water produced by ring-barking would not make itself apparent on the surface or in the water-courses or creeks. The volume of underground water would be increased, but not sufficiently to bring it to the surface of even as high as the beds of the creeks, and the increased volume would find its way to the main rivers by the old underground channels. The country upon which I have operated consists of basaltic ranges and valleys, some of the ranges of considerable elevation covered principally with white box timber, a species of eucalyptus not hitherto noted for very rapid growth or for any unusual power of withdrawing moisture from the soil. The height above sea level varies from about 1,300 feet to about 2,500 feet. The distance due east from the sea coast is from 70 to 80 miles; latitude $31^{\circ} 55'$, longitude $150^{\circ} 50'$. In no case is there any sand or gravel in the formation, but in other parts of the Colony I have known ring-barking to produce water in sandstone and gravelly country. The soil is not very deep, varying from two to three feet to about twenty feet, and the creeks all run on the basaltic bottom rock. It is a centre of long continued volcanic disturbance, surrounded on all sides by the older coal measures tilted against the volcanic ranges at various angles of inclination and broken up in every direction.

It may be thought that my experience is exceptional, and it will no doubt be asserted that the change which has come over the country which I hold since the forests were destroyed is due to other and unknown causes. The facts which I have given here are undeniable and may be verified any day, and I do not think my experience is exceptionable. It certainly is not in this part of the Colony, and I have made inquiry in many parts of New South Wales, and found in nearly all cases that the result of ring-barking was to increase the flow of water in the water-courses and cause the outburst of fresh springs. In one case on the Upper Namoi River, where ring-barking did not apparently increase the flow of water in the creeks, the banks of the river in many places just above water level became boggy, showing an additional inflow of water, which I think accounts satisfactorily for the non-increase in the smaller water-courses. The formation

there differed from that at Glengarry, and the increased volume of water in the ground caused by ring-barking evidently found its way to the main river channel through the lines of stratification, or through underground sand or gravel beds. Where this does not occur, and where the country is mountainous or undulating, the result of destroying the eucalyptus forests in New South Wales is I think invariably to produce an increased flow of water in the water-courses, and to cause springs of water to appear where before there were none.

With reference to the theory that growing forests attract the clouds, and so cause rain to fall in their immediate neighbourhood when without their presence it would not have fallen, I will not say much. Our present knowledge of the causes, apart from prevailing winds which determine the rainfall of any particular place from year to year, and make one year differ from another year, and one series of years differ from another series of years, is vague and indefinite in the extreme. We know that winds coming from certain directions generally but not invariably cause rain to fall or are accompanied by a fall of rain, and that winds from other directions are generally accompanied by dry weather, and we can make some sort of a guess why this should be so, but why the wind should blow more constantly from one direction one year, and from a different direction another year, we are unable to tell. No one, I am sure, will contend that the direction, force, and quantity of wind from year to year, can possibly be determined by forest growth or forest destruction at any particular place. The changes are far too rapid to be accounted for in this way, and the extent of sea and land over which a steady wind, lasting even for a week, will have travelled is so great that it cannot be accounted for by the local conditions of any one country or even of any one continent. If this be so, when we assert that by cutting down a few trees we are reducing the rainfall, or that by planting a few trees we are increasing the rainfall, are we not acting in much the same way as the fly which perched on the waggon wheel and exclaimed in exultation, "See what a dust I am making."

The rainfall records kept at Paris, and covering about two centuries, show no decline in the rainfall of that place, though the changes which man is capable of producing have been there very great within the time covered by the record. Some records in the Eastern States of America cover more than a century, and show no sign of any decline in the average rainfall, although in those States during the time over which the record extends, the amount of forest destruction going on has been greater than in any other part of the World. These records, like all others that have been kept for a sufficiently long period, vary

very much within not very well defined limits, always swinging back as it were but with the greatest possible irregularity, and the changes are not coincident either in time or sequence with any known local terrestrial or cosmical changes which might be supposed to have produced them. The reason of our inability to forecast the rainfall of any particular place, even for one year or one day, must be that the causes which determine such rainfall are infinitely numerous, and their interaction on each other so complicated that results are very rarely repeated. If this were not so, we would before now have gained even a little foothold of safe standing ground. As the ages roll on, if civilization and progress continue, gradually accumulated records and experiences may enable the scientist of the future to do what for us is impossible, but at present I am afraid the outlook is not hopeful. Our work is to accumulate the records and experiences.

Of course it may be contended that rainfall having been determined by other remote and complicated causes, might be slightly increased or reduced in quantity by the presence or absence of growing trees at any particular place. To prove or disprove this is impossible, until we are able to say beforehand in the presence or absence of trees what would have been the exact rainfall of any particular place on the earth's surface for any year or any series of years. In the absence of any such knowledge one way or the other, I think we may safely consider our convenience, and disregard even this much modified claim, which is by no means what is usually meant when people assert that forest destruction causes drought. There is one line of inquiry which I have often thought might possibly, if patiently and laboriously followed up, lead to some practical result in the way of enabling us to make some approach to the prediction of seasons for any particular place. It has not yet as far as I know been tried. With the most careful research, the finest instruments, and the greatest intelligence which the nineteenth century has produced, we cannot find for any given place in the varying records of the occurrence of droughts and floods, any order or sequence which will enable us to predict the season even for one year or one day in advance, or to say whether the coming year will be a year of drought or of flood; yet there may be a way different from that generally tried by which such knowledge might in some measure be gained. The attempt to find a saros for the seasons, like that discovered by the Chaldean priests for the moon's changes, has always failed, and there does not seem to be now even the slightest indication that such a thing will ever be found; but though we cannot predict the changes of the seasons for a century in advance as the moon's changes of position may be predicted, yet there may be a possibility of our attaining

knowledge sufficient to enable us to predict the seasons for a considerable time, perhaps more than a year.

I think it will be generally admitted that the total amount of heat which the earth with its atmosphere receives from the sun each year, is so nearly the same that there is no appreciable difference. Unusually cold summers or warm winters at any one place may be accounted for, and are accounted for by the varying distribution of heat on the earth's surface, caused by atmospheric and oceanic currents, but they do not affect the total of heat units. This being so, it follows that the amount of work done by the sun's heat falling on the surface of the earth, of lakes, of rivers, and of the ocean, in raising water by means of evaporation, and holding it suspended in the atmosphere, must be the same from year to year. Our atmosphere at a given temperature, or to put it in another form, charged with a given amount of heat, is only capable of holding in suspension a certain fixed proportion of water, so that after the point of saturation is reached, if the temperature be reduced, some of the water in some form must return to the surface of the earth or sea.

Now if the quantity of heat received by the earth be the same from year to year acting on the same surfaces of sea and land, will it not raise by evaporation precisely the same amount of water each year. If our atmosphere be only capable with the same amount of heat each year of holding in suspension the same quantity of water, is it not certain that there will be a like surplus in the various forms of rain, hail, and snow, to return again to the earth's surface each year. If this be admitted, it follows with absolute certainty that the total rainfall of the earth's surface, if under this designation we include all the forms in which water is deposited from the atmosphere, must be precisely the same from year to year, or can only vary within scarcely appreciable limits. Though we may not be able to say what the total rainfall of the earth amounts to, we may be fairly sure that it does not vary much if at all. This being so, it will follow that an excess of rainfall—a flood year—in any one part of the World must produce a deficiency of rainfall—a drought—in some other part of the World, or it may happen that a very slight reduction of the general rainfall may supply the excess which produces the local flood.

We cannot tell which of these explanations is true at present, but if the first be the correct one, we may possibly by comparing the rainfall records for different parts of the World, and over long periods of time, be able to find out in what particular places the droughts and floods compensate each other, and in what order of time; in fact, we may be able to say where our surplus rainfall comes from when we have a flood year, and where the proportion of our rainfall that is deficient has gone when we have a drought year. Such knowledge, if attained, would perhaps enable us to

predict the seasons for even more than a year, and would certainly be a valuable addition to the science of meteorology. The opinion which is prevalent in many parts of this Colony, that a droughty year in Europe will be followed here by a droughty year within a given time, seems to indicate a glimmering consciousness of some such connection as I have endeavoured to trace out.

In conclusion, I will say that for many years I have endeavoured to find upon what evidence rests the popular opinion that forest destruction reduces the rainfall of any country and dries up springs. I have seen many cases quoted where the occurrence of a severe drought was shown to be coincident with the destruction of forest in some particular place, but that would not prove anything, unless it could also be shown that droughts did not occur before the forests were destroyed, and would not have occurred if the forest had not been destroyed, and this part of the proof is always wanting. That large forest growths have been destroyed in many places without reducing the rainfall or the flow of water in the streams we have the most undeniable proof, but I do not think there is a single case recorded in the whole World where an accurately kept record of rainfall and flow of water in streams, or of either, shows a permanent diminution coincident in time and corresponding in degree with the gradual diminution of forests. That there is a connection between rainfall and forest growth there can be no doubt, nor can we doubt that they stand to each other in the relation of cause and effect, but the popular belief has reversed the order of this relation, holding the forest to be the cause of rainfall when it is in reality one of the effects of rainfall. From the well known power of the eucalyptus tribe to dry up swampy places, which has been made use of both in Europe and America, we might expect that the result of forest destruction where the trees were of this order would be much more decided and more quickly apparent, than where the trees were of a different kind like those of Europe or America, but the difference is, I think, only a difference in degree not in kind. In both cases the life of the tree is maintained in the same way, and we ought to find that forest destruction in Europe or America produced results similar in character to those produced in Australia, though perhaps they might differ in degree. For these reasons, I think, it is now time that those teachers of science in Europe and America, who hold by and teach the popular theory that forests do cause increased rainfall and an increased flow of water in springs and water-courses, and that deforestation does reduce the rainfall and flow of water in springs and water-courses, should reconsider their theory and the evidence on which it rests. This seems to me very necessary in the light of the experience gained in Australia, where forests are destroyed wholesale for pastoral purposes.

DISCUSSION.

Mr. F. B. GIPPS:—Mr. Abbott has entertained us with a most interesting paper on the effects of ring-barking or deforestation, which is the more valuable on account of its being the result of actual observation. If another such enthusiast, with opposite views and having similar advantages for observation, could be induced to enlighten us with the results of his investigation, we might by comparison of notes be able to arrive at more decided conclusions on this really most important subject, especially in a country like this so liable to droughts. It is to be hoped that this discussion may discover such an observer. For my own part I have little to add likely to assist in such conclusions, except an attempt to account for the breaking out of springs alluded to by Mr. Abbott, and to suggest some reasons why forests should attract rainfall. There is no questioning his premise that the breaking out of springs in a country denuded of its forests by ring-barking is largely affected by its physical and geological features. From his description of the geological features of the range of country covered by his observation, it may safely be presumed that the springs are of deep-seated origin, whilst his account of the topography of the country shows that it offers a favourable position for the bursting out of such springs when relieved to a certain degree of atmospheric pressure. But the flow of such springs is at all times more or less affected by the condition of the atmosphere. For instance, the approach of heavy rains is often indicated hours before by their suddenly bursting out afresh, or by their larger increase in volume because of the decrease in the pressure of the atmosphere. Doubtless the breaking out of springs noted by Mr. Abbot, is due to just the same decrease of pressure, only from another cause. In the latter instance this decrease is produced by the effect of the solar rays on the exposed surface of the ground, which gradually heats the lower stratum of air, causing it to expand. This expansion lessens the atmospheric pressure and thus induces the flow of springs. Perhaps there is no part of the country where this favorable condition for constant flowing springs can be better exemplified than at the summit of the Great Divide in the vicinity of Mount Kosciusko. Here we find innumerable perennial springs jutting out in every direction on the treeless table lands and slopes, whilst in the forests, only a short distance below, not a sign of a spring hardly is to be seen in summer time. This conclusively proves that there is a greater pressure of atmosphere

over forests than over exposed surfaces, and this is chiefly due to the cooler temperature the forests by their shade induce. A forest therefore, though in a modified extent, occupies much the same position relative to pressure of air as the ocean. The temperature of the sea is always more equable than that of the land, owing to the envelope or interposition of innumerable particles of water that serve to make it cooler in summer and warmer in winter than the land, and this coolness by attracting the overflowing air which I have shown the solar heat has forced upwards from the earth by expansion produces a high pressure on the sea. The same cause produces a higher pressure of atmosphere on forests than on exposed surfaces, for a tree interposes a large shade between the sun and the earth, and therefore lowers the surface temperature by day and induces humidity by preventing the too rapid escape of moisture beneath it, and at the same time by its shade it protects the ground from evaporation. But the atmosphere just above a forest is constantly absorbing moisture therefrom, and therefore it is lighter than the current just above it again, so that it is constantly forced upwards. As these currents ascend they gradually become cooler, and should their aqueous vapour meet a stratum of air already laden to dew point, their additional moisture produces rain. Thus it appears to me that the very occurrence of springs, as noticed by Mr. Abbott after the destruction of the forests and where none apparently existed before, affords pretty conclusive evidence that a condition has been produced by ring-barking unfavourable to rainfall. Again, this lowering of the summer temperature and raising of the winter temperature by forests, is the very cause that induces constant change of currents productive of rainstorms, for it has been proved by the charting of winds with isobarometric lines, that the wind and consequently the rainfall depends on the pressure of the atmosphere, and therefore on its temperature and humidity. It has been shown, also, that winds chiefly blow from places where the pressure of air is high to places where it is low, and that variable winds are affected by local causes, such as the physical features of the country whether level or mountainous, the vicinity of sea or lakes, and lastly such as the prevalence of forest or desert country. We know, too, that given in any locality an excess or decrease of atmospheric pressure, temperature, or moisture, certain atmospheric changes inducing wind take place to restore the equilibrium thus disturbed, which again influences rainfall. Now forests, on account of the aqueous vapor rising from them and the greater pressure of air above them, offer conditions favourable to these atmospheric changes, and consequently favourable to the increase of rainfall. Thus it seems to me that forests must have a direct influence in inducing rainfall, for which reason they should be carefully cultivated. Whilst then I

would destroy all useless trees, I would suggest that especial attention should be given to the cultivation of thick shady deciduous trees in their place, such as the chestnut, walnut, plane, and sycamore trees on the plains and moderately elevated table lands of the interior, whilst the most valuable species of Californian pines and cedar should be cultivated on the coast range, in order to induce as much as possible that alternation of currents favorable to rainfall.

Mr. H. C. RUSSELL (Government Astronomer):—I should like to occupy the time of the Meeting for a few moments, to give expression to some of my own views upon this subject. It is one, as some of the members know, I have paid some attention to and have taken a great interest in, and it is not long since I endeavoured in the public prints to show that the result of investigations carried on in France, England, and America, in what seems to me the most conclusive way of testing the effect of forests on rainfall has been that no such effect can be discovered. Meteorological observations have been carried on in France for about 200 years, and no decrease in the rainfall can be discovered whatever, although the population of France has increased, and necessarily the amount of forests destroyed has been very great during that period. The same has taken place in England and in America. Now to my mind that is the strongest evidence of all. A great deal has been made of experiments carried on with the intention of showing that the temperature of the forest is very much lower than the surrounding area, and that the amount of rainfall deposited on the forest is much greater than that deposited on the plain country near it. But these experiments have continued only for a short time, and the evidence of different observers is so contradictory that it must be taken for what it is worth. It is a difficult thing to ascertain what is the amount of rainfall on a forest as compared with plain country near it. Then again we have statements published that forests are warmer than cleared country at night and cooler by day, and it has been asserted that because forests are cooler therefore more rain is deposited on them. I think those who say this must have overlooked the fact that if the forest is cooler, it is very little cooler, and is a very small body compared with the great extent of atmosphere above it; and everyone knows that if two masses of air of different temperature are brought together they soon take the mean temperature of the two, but the forest being but little cooler than the atmosphere and insignificant in extent relatively, it can have scarcely any effect in lowering the temperature of rain clouds. Again, Nature has provided us in New South Wales with a great stretch of plain country and alongside of it a great extent of forest. From a careful examination of the rain records on both, extending over several years, I cannot detect any difference in the proportion of

rainfall in the plain country and in the forest country, we are therefore in a position to say that our forests do not increase the rainfall. Again, it has been conclusively shown within the last few years that nearly the whole of the circulation of the atmosphere is a circulation in what is technically called the cyclone system. We all know what a cyclone is in the ordinary sense of the term, but it is only recently known that every wind is moving under the same laws as do those in intense and therefore dangerous cyclones: in fact, whenever we have a breeze or disturbance of the wind: that wind depends upon the relative heights of the barometer and on certain other circumstances. These ordinary cyclones are of enormous extent, and rain is found to be a necessary part of each cyclone. It is just as essential a feature of the cyclone as that the circulation of the wind is due to a fall of the atmospheric pressure, and further that the rainfall which we get from these storms is practically the whole of the rainfall that is deposited on the surface of the earth. Rains may occur in other ways, but the amount is relatively quite inappreciable, in fact, whenever it falls part of a cyclone system is passing over. These cyclones are from 1,000 to 3,000 miles in diameter, and such a system passes over the earth's surface just as a railway carriage passes over it, according to definite known laws at a definite rate, although the rate varies from 7 to 20 miles an hour, but still you find that the cyclone is travelling across the surface of the earth, and it is very little affected by the surface conditions. I do not see, therefore, how it is possible that the cutting away of a few trees over a mile or a hundred miles, can in any way affect the circulation of the atmosphere in these enormous cyclones which often cover six to eight millions of square miles. That to my mind is a very strong argument against the statement that cutting down forests will affect our rainfall. There is another point: with regard to the cutting away of forests, and their effect upon rainfall. We know from a paper Mr. Abbott read here some time ago that three-fourths of the forest land in the Upper Hunter has been destroyed by ring-barking, yet if you examine the records, the rainfall in that ring-barked country is just the same as on the surrounding country which is not ring-barked; and I think that is also a strong argument in favour of the view that forests do not affect rainfall. There is another circumstance not of so much importance, but still worth mentioning. Last year the rainfall in this Colony was heavier than it had been for any year before, since records have been kept. I ask those who argue that trees produce rainfall if it is possible that one year's rainfall should be so excessive compared with others because trees have been planted, and if the planting of trees last year or the year before produced the rainfall of 1887, what has produced the drought of 1888? Not the cutting down

of those trees certainly, because they have not been cut down. I should like to say also that, as far as I have been able to investigate the statements that forests produce or increase rain, generally no data are given *i.e.*, the rain measures on cleared and uncleared forest are not given, in fact there is no scientific data to go upon. I would point out that not long since a gentleman holding a high position in a neighbouring colony made a statement, as reported by an officer in the Austrian service, that millions of trees had been planted in Victoria, and streams had burst out in more than one hundred places. That is the kind of statement usually made, and, upon enquiry, I found there was not a single instance in which there was any evidence that the planting of these trees had produced streams of water. These statements have been made for a long time till it has grown popular to believe them, and it is quite sufficient for the majority of persons to follow a popular belief.

Mr. MANN :—The result of my experience in this, tends to show that ring-barking forest trees materially encourages the growth of other vegetation. Large tracts of country which, previous to undergoing this process, were poor, barren wastes, almost destitute of water, are now well-grassed lands, and water in places rendered permanent or easily obtained. The amount of moisture drawn from the soil by a large tree, to be partly absorbed by the atmosphere by means of the leaves and branches, is something enormous. This is most noticeable in the Illawarra and Coast Districts, where the vegetation is semi-tropical, and extremely dense and succulent. Unfortunately ring-barking has generally been performed in a reckless manner, so that much valuable timber has unnecessarily been destroyed, while no shelter has been retained for the protection of stock. Regarding cyclones I have traced several for many miles by means of the fallen timber which occupied a strip of country of from one to two hundred yards wide. These cyclones are very destructive, and *twist* the heads off a tree rather than level it. Although the facts given by Mr. Russell show conclusively that forest country exerts no influence over the rain-fall, it is possible, that in crossing an open plain, a cyclone bearing rain-clouds might be diverted from its course by large patches of forest, and so cause a fall of rain at those parts. I am under the impression that the erratic seasons we have had during the last few years will be shown to be the result of large islands or fields of ice, which have drifted within the climatic radius of this country. Not having a Gulf Stream to regulate the temperature, we are more susceptible to other influences.

Hon. G. H. Cox :—All those engaged in agricultural or pastoral pursuits in the country agree that this is a matter of

extreme importance. I have given this matter of ring-barking much attention, and have come to the conclusion just enunciated by Mr. Russell, that the forests can have little or no influence whatever upon the rainfall. I think people as a rule confound cause and effect. I know that on the eastern coast we have large forests and heavy rainfall. It is not the forests that cause the rainfall, but the heavy rainfall that causes the forests. I am also aware that the statements made by Mr. Mann can be borne out. I know of two instances in which ring-barking has caused springs to flow where they were not known before. I account for it in this way. When trees have been killed, the rain instead of falling only partially upon the earth falls wholly upon it, and falling upon the decayed leaves of these trees forms large reservoirs and breaks out into springs. Another curious matter. On the higher mountains, Mount Wilson for instance, when you denude the country of trees you make it very much drier. That is not the rainfall. It is the mists coming up from the sea. After a warm summer's day a cool wind springs up from the sea and brings up a mist. This mist is caught by the trees and vegetation, and hangs upon these and produces a large amount of fall. The ground is quite wet, and where there has been a denudation of trees the ground is quite dry. I am a believer in ring-barking; I do not believe it has any effect on the rainfall, but it tends rather to produce more moisture in the soil than was previously present.

Mr. HENSON :—While listening to Mr. Abbott's paper at the last Meeting, the thought occurred to me that the permanence of the flow of the water in the streams after the forests had been cut down, was largely due to the decay of the roots as mentioned by the last speaker. The ramifications of the roots of forest trees are very extensive, and after the trees have been cut down these roots decay, and form channels through which the water readily passes into the ground. The formation that surrounds us in the western suburbs is dense shale formation. The upper portion has been comminuted by rootlets. Many know the large forests that formerly grew in these districts. As those trees have been cut down, the water has penetrated along the rootlets and found its way into the ground. Of course the clay, which has been formed from the shale, retards the lateral travel of the water, but still the ground does absorb an immense amount of water after the trees have been cut away. Another thought occurs to me. A rain gauge placed at ground level I believe records a larger amount of rain than one at some height above the ground. Would a rain gauge in a forest amongst the trees record as much as on a plain adjoining? A portion of the rain must be intercepted by the foliage; the twigs and the trunk become thoroughly wetted, this

moisture does not fall to the ground and is removed by evaporation.

MR MANN :—On the Illawarra the decomposed leaves are never dry. There could never be a fair test.

Mr. RUSSELL :—It is usual in taking observations to determine the rainfall in forests, to place one rain gauge on the ground in the open near the forest, and another in the forest in a place where the trees are cleared away, the reason, no doubt, why an elevated rain gauge catches less rain than one on the ground is that the velocity of the wind is greater as you rise from the surface of the ground, and the mouth of the gauge produces a little vortex motion of the wind which throws the rain out. The question has never been thoroughly investigated as to what effect, if any, forests have upon the rainfall, in fact it would require a great many years of observation before the question could be settled.

Mr. W. M. HAMLET :—I quite agree with Mr. Russell, that we have no scientific data to enable us to determine the effect of the rainfall in connection with forests. It appears to me one thing has been lost sight of in connection with this discussion, and that is the natural function of the leaf of a tree, namely, that of evaporation ; and my own idea is that we may account for the occurrence of these springs after ring-barking in this way. Let us take the total area of all the leaves of a tree or a number of trees, and compare that with the area of the ground upon which the tree stands, the total area obviously will be considerably greater. Now, during a tree's life evaporation is going on, and water is being drawn up from the soil in order to produce the effect of growth in the tree. After ring-barking evaporation ceases, and there being no longer any outlet for the water from the soil, it must necessarily follow that the water which is already in the soil, and which has been accumulating in consequence of repeated rains, must find an outlet. That, I think, will account for the boggy nature of the soil after ring-barking under the conditions stated by Mr. Mann. Then, with regard to the remarks made by the gentleman who opened this discussion to-night. He said that there was a difference of atmospheric pressure on forest land—that there was a greater amount of pressure on forest land than on cleared land. I think that is utterly erroneous. I think if we took a barometer and stood it in a forest, and then took it to cleared land in the vicinity, there would be absolutely no difference whatever with regard to pressure, and that the diminution of pressure in any one place would not account for this previously dry place becoming covered with streams of water. I think the true explanation would lie in the question of evaporation.

Mr. GIPPS :—I said in the light stratum *just above* the forest, not *in* the forest.

Mr. ABBOTT, in reply, said :—I have not much to add to what I have written in my paper. I regret a little I did not quote more largely in the paper from a paper I read some seven or eight years back. I referred to the paper, but did not give the particulars there given. It is now about twenty years since ring-barking began on the piece of country I referred to in the paper. Then after ten years had elapsed, and the springs had remained permanent during that time, I made measurements of the water flowing in the creeks where it had been dry before, and those measurements gave a very large flow of water where there had been no water at all, proving that all the water thus measured was water that would not have been there at all except for some change, and the only change I knew was the ring-barking of the forests that had been destroyed. I waited then for eight years more, after some very severe droughts had occurred in this and other Colonies. I found these springs were not affected. They still continued to flow. I think that proves that Mr. Gipps' theory that the ring-barking alters the barometrical pressure over the country must be wrong, because a barometer does not remain permanently raised or lowered. If the springs were affected by the rise and fall of the barometer they would stop or flow. But they are not affected—the water has a regular flow. In the paper I read some seven or eight years ago for this Society, I referred to some observations by Professor Draper. He was the President of the Observatory at New York. Questions were put to him by I think the Legislature of New York for the purpose of settling whether the cutting down of the forests would cause a diminution in the water supply to the city of New York. Professor Draper, who was I believe a very eminent scientist in America (I suppose he was the most capable man they could find), examined into the matter with reference to the rainfall where records were kept in the Atlantic States of America, these records extending over nearly 100 years I think. He also took the records in Paris extending over nearly 200 years. The conclusion he communicated to those who put the question was, that the destruction of forests had not in any way affected the rainfall. He showed in his report that neither the temperature of the Atlantic States of America nor the rainfall had altered in any appreciable degree during the last century. I think that opinion is as good as any we are likely to get now. As to another matter raised in this discussion: the difference in the rainfall in forests and the open country. I have seen it stated that the temperature was lower in the forest, and therefore it must condense the moisture. It has always seemed to me that if the temperature is lower in the

forest, that lowering must be produced by evaporation, just as when we expose a water-bag to a dry atmosphere the water then becomes cool: below the temperature of the air—that is due to a physical law there is no escaping from. While evaporation goes on the temperature in the forest would be lower—as soon as the evaporation stopped the temperature would rise. Therefore I incline to the opinion that the temperature in a forest is not lower during rain—it is only lower in dry weather. I would also call attention to the matter Mr. Russell referred to, that nearly all these statements that the rainfall is increased by forest growth are merely theoretical. They are not the result of actual observation extending over a long period. But with reference to this piece of country I wrote about, I have my own personal observations extending over a period of 26 or 27 years, and the land has been in the possession of my family since 1848. All these creeks were dry up to 1869. From 1869 up to the present time (19 years) they have been running permanently; so that all these cases are matters of fact known to myself. We must be guided by fact in preference to theoretical ideas that forests condense the moisture. Another thing is, that this effect of deforestation of which I wrote is not confined to any small area of New South Wales. I find that in every part of this Colony from which I have been able to get information the same effect follows more or less. Another matter. In the thick forests on the coast range the dead leaves lying on the ground are never dry, but I do not think that proves anything at all, because in these rich brush lands the rainfall ranges from 120 inches. That is the reason why the ground is never dry—it is continually saturated with rain. There is no doubt that these forests on the coast range are produced by the rainfall, and not the rain by the forests. Allow me to refer to something that happened. When I wrote the paper for this Society in 1880, all the references made in that paper were to one particular area that had been ring-barked. At that time there were a number of creeks flowing eastward from a certain range. From that time up to now on the western side of that range the creeks all remained dry, while those in the eastern ring-barked side were running. Within the last two years I have ring-barked the western side, and new creeks are beginning to run permanently on that side. It follows almost immediately on the dying of the trees, generally within 18 months.

Rev. S. WILKINSON :—Two thoughts have occurred to me which at this stage of the proceedings may be just worthy of notice. Firstly, the ornamental point of view. For this object I have often been grieved to see that when forest land has been cleared, some portions have not been allowed to remain. Then there is the economic, I may say the humane point of view. In some

cold districts I have seen the cattle exposed during winter nights without any shelter whatever, causing also a considerable loss to those engaged in dairy pursuits. I think it is greatly to be regretted that any stock should unnecessarily be thus exposed to the inclemency of the weather.

Mr. ABBOTT:—I have not known of any permits being given of late years to ring-bark that did not stipulate for some timber being left growing for purposes of shade and ornament. The Local Boards, in whose hands the matter is, do not permit indiscriminate ring-barking.

Hon. G. H. COX:—I move a vote of thanks to Mr. Abbott. I have read with pleasure the papers written by him.

Mr. RUSSELL:—I second the proposition. I think everyone, whatever may be his views upon the scientific question as to the effect of forests upon rainfall, will admit the national importance of preserving a certain quantity of trees, and planting forests where they are required. The misfortune is that questions of this nature get mixed up. But we are not discussing the question whether they are useful for commercial purposes. It is a scientific question that is being discussed now, viz.: whether trees produce or increase the rainfall. Whether trees do affect the rainfall or not I am sure every care will be taken by the Government of this Colony, as in other countries, to preserve a certain number of trees. But as I have said, that question is not being discussed to-night, but simply the scientific question.

The PRESIDENT then put the motion, which was carried unanimously.

ON THE INCREASING MAGNITUDE OF ETA ARGUS.

By H. C. RUSSELL, B.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

THIS remarkable star, which so surprised Sir John Herschel in 1837 by its sudden increase in magnitude, and which continued to increase until it was brighter than every star in the heavens, Sirius only excepted, has I think passed its minimum recently. It will be remembered that after reaching its maximum about 1843, it fell a little, but was still a bright 1st magnitude star until about 1856, when it began to fall rapidly, and by 1859 was only of the 3rd magnitude, and has ever since been going down in the scale of magnitude, until some have been led to think it would rise no more.

In 1871, when I carefully surveyed the whole cluster in which it stands, Eta was of the 7th magnitude, or adopting Gould's Standard of Star Magnitudes, which has been carefully prepared, my estimate of Eta was 6.8 magnitude. On 4th February, 1874, I was surprised to find it $\frac{1}{2}$ a magnitude smaller than in 1871, or 7.4 magnitude, and I have since been in the habit of frequently examining it and comparing it with several stars in its own cluster which are not variable. During the years 1875 to 1882 the change seemed to me inappreciable, but in 1883 the estimates varied from 7.5 to 7.8, in 1884 I made it 7.6, in 1885 and 1886 about the same, although in the latter year I several times thought it was getting brighter, in 1887 I was away, but the first examination on my return removed all doubt, there was evidently a very decided increase; adopting still Gould's Magnitudes for Stars of Comparison, I find Eta at the end of May, 1888, was of 6.9 magnitude, or almost as great as it was in 1871. These comparisons were made in the usual way, viz., by estimating in the telescope relative brightness of the star images.

But I have also compared it with six stars in its own cluster (the same stars used by the older method) by means of a wedge photometer, 180 measures have been made, and give the magnitude 7.24 as a result. I have also compared it in the same way with six stars in Kappa Crucis cluster, 90 measures have been made, which give the magnitude 7.42. My experience with the wedge photometer has been that red stars, of which Eta Argus is one, are made to appear smaller than they do by direct vision, or in other words, that red light is more absorbed by the wedge than white light, so that the magnitude of a red star by wedge photometer is smaller than it should be, and as appears in the foregoing, where direct comparison makes it 6.9, and the wedge 7.24. As all my previous comparisons were direct, and I think also those of other observers, we must take 6.9 as its present magnitude, and comparing this with the mean of my estimates for 1883 to 1886, or 7.64, it appears that Eta is now $\frac{3}{4}$ of a magnitude brighter than it was in 1883, and increasing rapidly, so that should the present rate of increase continue as we have every reason to believe it will, Eta will soon be visible to the unassisted eye again, which it has not been for 20 years.

In 1869 Prof. Loomis collected the then existing observations of Eta Argus, and came to the conclusion that its range was from the 1st to 6th magnitude, and its period 70 years, with minimum about 1870, but as you have just heard the minimum did not occur until about 1885, or 15 years after he supposed it would, and the magnitude got down to 7.64 instead of 6.

The previous minimum occurred long before there were any regular observers of the star's magnitude, and therefore we cannot

say definitely when it took place, but it seems probable that the period is about 80 years ; it is about 40 years since its maximum, and carrying this backwards, the observations since 1800 and the two previous ones in 1751 and 1677, will fit into places on the curve, 1751 by Lacaille at the Cape, 1677 by Halley at St. Helena.

It must, however, not be forgotten that this star when near its maximum was subject to remarkable fluctuations in brilliance, and it seems probable that it would present the same character at minimum, and such has been shewn by observation ; but the present increase in brilliance is so considerable, that I think there can be no doubt that the minimum is past, and that Eta Argus will again be a brilliant star in the heavens.

NOTES ON SOME MINERALS AND MINERAL LOCALITIES IN THE NORTHERN DISTRICTS OF NEW SOUTH WALES.

(With one Plate.)

By D. A. PORTER, Tamworth.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

IN a paper read before your Society on 5th Nov., 1884, I had the pleasure of offering a few observations on "Some Minerals and Mineral Localities in the Northern Districts of New South Wales," and I purpose in this paper to continue the same subject, as I think it is very desirable that every mineral locality in the Colony, so far as known, should be noted, so that they may be easily discovered by those who, in the future, may desire to submit them to further examination. The notes contained in this paper are the result of personal examination of the various minerals and localities referred to herein.

GOLD.

As gold is so widely distributed throughout the northern districts of this Colony, and as all the localities in which it occurs are well known and catalogued, I purpose only mentioning it in instances where something unusual is connected with its occurrence, such as its association in alluvial or matrix with other minerals or metals.

ALLUVIAL GOLD WITH METALLIC COPPER

Is found at the source of Wet Creek, near Mount Misery, Nundle. An assay of 100 grains of the sample gave—

Gold	...	...	...	...	23.0
Copper	...	...	...	...	61.0
Iron Oxides	...	...	...	...	10.0
Loss	...	...	...	...	6.0
					100.0

The iron oxides occur as magnetic and titaniferous iron. Professor Liversidge, who examined a sample forwarded by me in 1882, says, "The particles of metallic copper are much smaller than those of the gold, the latter, however, do not exceed a square millimetre in area. The gold is not much water-worn, and under the microscope is seen to be distinctly crystallized in parts. The grains of copper, although of more or less spherical form and with mammillated surfaces, are in some instances distinctly crystallized." Slates, jasperoid rocks, and serpentines occur in the vicinity, and are overlaid in part by basalt. No work has been done in this locality since it was first prospected in 1882, as the gold was found not to exist in payable quantities.

GOLD WITH SULPHIDE OF ANTIMONY AND ARSENIC.

Gold associated with stibnite and arsenic, or some arsenical compound, occurs in a large quartz-vein in the "Ellenora Gold Mining Company's" property at Hillgrove, about fifteen miles in an easterly direction from Armidale (N.E.*). Although when observed casually the particles of gold often appear to be attached to the stibnite, yet so far as my observation has gone, in no instance is this the case, close examination reveals the fact that each and every particle of gold although *almost* inclosed by the stibnite, is seated upon a larger or smaller particle of quartz. The arsenic is not observable in the stone or ore until heated in the kiln, when large quantities of the oxide condense in brilliant octahedral crystals in the cooler parts.

GOLD IN MISPICKEL.

At Bowling Alley Point, near Nundle, some fine specimens have been obtained from the "Carrington Reef." The gold bright and clean, and penetrating the mispickel in wiry forms in every direction.

GOLD IN CALCITE.

At Tea-tree Creek, about twelve miles S.E. from Barraba, in thin branching filiform masses. The calcite is white and opaque, and cleaves readily into rhombic fragments. Some specimens of pure white calcite, with the gold projecting from the cleavage

* N.E. is a contraction for the New England District.

planes of the mineral, are very handsome. Very beautiful specimens are obtained by dissolving the calcite, as the gold is then left in the most peculiar and fantastic forms. The auriferous calcite is found in veins traversing clay slates.

At Bingera, two miles S.E. from the town, in serpentine. A sample gave a return for gold at the rate of 9 dwts. per ton. The calcite in this locality differs from the auriferous calcite of Tea-tree Creek before mentioned, in being made up of thin plates, which are contorted and interlocked. The laminæ are, however, easily separated, and the surfaces are seen to be dull. These separated, thin plates are easily broken across in one direction, exhibiting small bright cleavage planes. The contained gold occurs in isolated particles, the largest of which would not be more than $\frac{1}{16}$ grain in weight. Small crystals of pyrite are also present in the calcite.

NATIVE ANTIMONY.

At Hillgrove Antimony Mines, fifteen miles easterly from Armidale (N.E.), in small isolated deposits in the vicinity of veins of stibnite. Amorphous, compact, colour and streak tin white. Hardness between 3 and 4, scratches calcite, Sp. G. 6, 69. Fracture irregular, rough; cleavage on small faces, imperfect. B.B. fuses easily, and becomes covered with prismatic crystals of oxide of antimony. Not of common occurrence. The country is principally of slate, more or less altered, and inclined from the horizontal at a high angle. On the northern side of the mines gneissic rocks are found outcropping. The principal mineral veins of the locality are found in the slates, and are composed of an amorphous quartz as the matrix. These quartz veins are in places accompanied by casings of a tough greyish rock, composed of whitish to colourless felspar, and dark green hornblende. At low levels in the ravines on the southern side of the principal mines this rock, which is probably a trachyte, is found as intrusive sheets, which appear in some measure to follow the bedding of the slates.

ANTIMONITE (Stibnite).

At the Hillgrove Mines before mentioned, associated with arsenic and gold, in quartz veins traversing slates. The best deposits of stibnite are generally found on the outer sides of the veins, near either the 'hanging' or 'foot' walls, but more or less of the ore is distributed through the quartz. Pyrite in small quantities is found in the stone, but no mispickel nor arsenical iron was observed, so that in what form the arsenic exists in the ore has not yet been ascertained. The antimony mines of this locality are now worked principally for the gold present in the quartz, as the low price of antimonial ore, at the present time, renders it of only secondary importance.

At Nundle, near the old flour mill in Oakenvale Creek, and extending thence in a northerly direction into Happy Valley. This lode has been prospected and deserted. The vein is small, and very irregular in width, from two to twelve inches, and the ore appears to be of inferior quality. This vein is in hard, jointed, argillaceous slates, which are much tilted.

On road Bendemeer to Walcha, seven miles from Bendemeer, in hard micaceous schists. The vein of ore appears to be about eight inches in thickness. No prospecting has been done in connection with this deposit beyond sinking two or three feet on the outcrop.

MOLYBDENITE.

At Wilson's Downfall, thirty miles north from Tenterfield, and one and a half miles westerly from Wilson's Downfall Post Office, in thin leafy forms in vein of milky quartz, traversing granitic rock; not common.

At Hogue's Creek, twelve miles north from Glen Innes (N.E.), near road to Tenterfield, in large quartz lode, associated with wolframite, chlorite, tin ore, and native bismuth. In thin brilliant plates, often inserted between crystals of quartz in geodes in the rock; not very abundant.

At Kingsgate Bismuth Mines, twenty miles east from Glen Innes (N.E.). Often accompanying wolframite and ores of bismuth, but in greatest quantity in large deposit of bluish-grey crystalline quartz, which, like that of the Hogue's Creek locality, has a coarsely granular appearance, and is easily broken or crushed. Crystals of molybdenite are not uncommon in this locality. They occur as low hexagonal prisms, rarely more than $\frac{1}{4}$ inch in length by $\frac{1}{2}$ to 1 inch across, rarely 2 or 3 inches broad. These prisms or plates are composed of very thin horizontal laminæ, which are easily separated from each other. The laminæ, often contracted in size, successively, from the lower ones upward; thus forming a bevelled edge, which in turn would ultimately form a hexagonal pyramid, were the process continued far enough. No such terminations to crystals were, however, observed. The molybdenite crystals are almost invariably depressed in the centres, as shewn in section (figure 13). Molybdenite in leafy and fan-like aggregations and deposits occurs in large quantities in this locality. Colour, lead-grey, brilliant metallic lustre on fresh cleavages. Soft, easily scratched by the finger nail; marks paper like graphite; opaque. Thin laminæ, by transmitted light, blood-red. The deposits of molybdenite, bismuth, and other minerals, at Kingsgate, occur principally in pipe veins, and in irregular masses of quartz rock, in coarsely granular feldspathic granites.

ACTINOLITE.

At the Woolshed Gap, on road from Barraba to Bundarra, in radiated masses of slender prisms, in connection with a large vein of milky quartz in granite. The mineral is in places attached to the quartz, or penetrating it, but masses free from quartz occur, up to five or six pounds weight. Colour, brown or black, some with greenish tinge. Opaque in mass, but separate prisms translucent.

At Giant's Den Tin Mines, near Bendemeer (N.E.), on the highest peak of the Giant's Den Nob, in acicular crystallizations on cassiterite, and in radiated masses on opaque quartz; greenish-brown to brown, and nearly black.

Actinolite occurs in many places in the New England tin mining districts, in small veins, or in radiated isolated masses, more rarely in acicular crystals penetrating crystals of colourless or smoky quartz. Actinolite rock in water-worn pebbles and small boulders, is common in the alluvial tin workings two miles S.E. from Tingha (N.E.). These pebbles and boulders are very compact and tough, and often show a radiated internal structure when broken.

AXINITE.

At Bowling Alley Point, near Nundle, in granular masses and small crystals, with green epidote, in quartz vein, traversing hard splintery slates, on ridge about 150 or 200 yards south from the iron foot-bridge. Colour brownish, with pink tinge when newly broken; occurs only in small quantity.

BERYL.

At Glen Creek, near Emmaville (N.E.), two miles north from Dolcoath tin lode, *in situ* in small mineral vein, traversing indurated clay slates, associated in druses with crystals of topaz, quartz, and cassiterite; found also in isolated prisms embedded in the rock. Crystals transparent, rarely opaque, bright green to colourless. The largest crystals not more than $\frac{1}{4}$ inch in length by $\frac{1}{8}$ inch thick; generally striated longitudinally, but some with flat smooth sides, some crystals with terminations like figure 8, but mostly rough pointed like figure 9. The green colour is often distributed unequally in the prisms. The associated crystals of topaz are usually larger than those of the beryl, but are generally full of greyish-white cloudy matter or dark coloured inclusions, and abound in gas pores. Some of the smaller crystals are very brilliant, transparent and sound.

ZIRCON.

In the Inverell District zircons are found in many places over a large area, chiefly of basaltic country, forming the watershed of the Macintyre River on the northern side, and extending from N.

to E.S.E. from Inverell. They occur principally in the beds of streams, or scattered over low sloping ridges, and in the beds of clay and boulders, which form raised beaches along the creek sides, in many of the localities. The boulders in these old beaches are very much rounded and worn, and have been derived from the porphyrites of the surrounding country, which before the outpouring of the recent volcanic rocks, obtained as the principal rock formation of the localities referred to. The best zircon country is about Paradise Creek (County Gough), on many of the low ridges, and in the beds of the tributary watercourses between Upper Paradise Creek and the Swan Vale waters; in Swan Vale Creek and on the ridges on the northern side of same, extending from the Swan Vale Post Office to eight or ten miles westerly; at Apple Tree Gully, fifteen miles north-east from Inverell; at Swamp Oak Creek, and Frazer's Creek, on road from Inverell to Wellingrove; on road from Glen Innes to Inverell, two miles west from crossing of Waterloo Creek, in Macintyre's Lane. The zircons from these several localities mentioned, are usually more or less broken or cleaved, and very much worn and smoothed, but occasionally in fairly perfect crystals, of which figures 1 and 2 are representations. Some of the worn fragments, clear and colourless, have been observed of from four carats to eleven carats weight. The crystals are generally not much modified. All observed were prismatic, but rarely with double terminations. Colour, pale amber tint to colourless; transparent, rarely opaque, Sp. G. of six stones collectively = 4.547. The accompanying minerals seem to be of a similar kind in all the before-mentioned localities, consisting of smooth waterworn fragments of milky quartz, quartzites, pebbles of reddish-brown, yellow, buff, and black jaspers, and broken and worn fragments of pleonaste and sapphire. The pleonaste occurs rather plentifully, in pieces often $\frac{3}{4}$ inch in size, and occasionally in nearly perfect crystals. With the pleonaste, sapphire, and zircons, small rolled very highly polished pieces of black hornblende are sometimes found.

Zircons are met with at Elsmore, Stony Creek near Tingha, and at Red Hill, on Cope's Creek, above Tingha, as well as in several other places in the same district, as the principal constituent of a fine greyish sand, which is with difficulty separated from the finer of the stream tin ores. Under a magnifier the crystals are seen to be very perfect in form, long prisms with double terminations prevailing. Colour, pale yellowish, to grey, mostly transparent and of extremely brilliant lustre.

At Tilbuster, three miles north from Armidale, in creek bed, with gold and sapphires, generally in smooth almond shaped pieces, or broken fragments, often five or six carats weight; larger pieces

rare. Colour, garnet red, transparent. Formation, granite, basalt, slates and conglomerates.

At Lyndhurst, thirty miles north-east from Armidale, in creek near Lyndhurst homestead, in pieces more or less rolled, and up to half-ounce in weight. Generally translucent, or opaque, small pieces transparent, colour pale sherry-red to brownish-red. Hard splintery argillaceous slates prevail in this locality.

At Rocky River gold-field, near Uralla (N.E.), in auriferous drifts, with titanite iron, topaz, and sapphire, the latter only in small fragments and rare. Colour, wine red, pale red, greyish, rarely green, some small crystals ruby red; transparent to opaque. Sp. G. 4.55 to 4.56. The zircons in this locality occur as octahedrons, formed by the association of the terminal tetragonal pyramids. The prismatic form, if at all existing, must be extremely rare, as not one example was observed in the examination of some thousands of specimens. Crystals more or less fractured, but not appreciably worn; the smaller crystals, as usual, being the most perfect. Large pieces occasionally, but not of common occurrence; three of the largest pieces noticed weighed 45, 39, and 15 carats. Sp. G. 4.55 to 4.64. Colour, garnet red; transparent, but slightly flawed.

At Oban (N.E.), in the Ann River, in waterworn pieces, with red spinel, sapphire, topaz, cassiterite, gold, and titaniferous iron; rare. Colour, pale yellowish red. A stone from this locality weighed 48 carats, but contained flaws and blemishes. Sp. G., 4.64.

In the Mann River and Bald Nob Creek, near Glen Innes, with stream tin ore and corundum. Nearly colourless to pale reddish. The paler coloured stones often with patches of deeper colour in part; very much waterworn, transparent, translucent, rarely opaque; common in pieces 5 to 8 carats.

At Nundle gold-field, in the auriferous cemented gravels of Mount Pleasant, and less plentifully in several other parts of the field. At Mount Pleasant the associated minerals are chromite (in small black shining octahedrons), magnetite and other oxides of iron; small quantities of titaniferous iron sand are usually present. The zircons do not occur in any very considerable quantity, an ounce or two, only, being contained among the concentrates from a month's ground sluicing. They are generally much worn and with smooth polished surfaces. Occasionally perfect crystals are met with, which almost invariably have very short prisms and modified terminations, the normal planes and faces being often nearly extinguished by the replacement of edges and solid angles. Simple forms rare; crystals and fragments small; rarely more than $\frac{1}{16}$ inch in area. Colour, pale amber

yellow to sherry red, transparent, opaque. Fig. 14 is of a crystal from this locality, it is however exceptional with reference to development of prism.

SPINEL.

At Oban (N.E.), in the Ann River and above its junction with the Mitchell River, also in the Mitchell River, in rounded pieces with rough surfaces, appears as if little waterworn, but without trace of crystalline form. Colour, dark wine-red, transparent; observed up to 15½ carats in one specimen, average for six others 6.6 carats each. The spinels from the Ann River are generally free from flaws and imperfections. Sp. G. 3.69, hardness over 8 scratches topaz readily. Found with gold, tin ore, titanite iron, topaz, zircon, and sapphire. Fragments of spinel are found with gold and other minerals at Bingera, Rocky River, and Nundle goldfields, but are generally small or opaque. A piece from Uralla weighed considerably over 1,000 grains, had a Sp. G. of 3.81, was rose-red, but dull and opaque, and very much waterworn.

GAHNITE.

About half-a-mile west from Great Northern Railway, at a point about two and a half miles north from Bolivia Railway Station. Occurs as a lode or vein ten to twelve inches wide, in granite. Massive, crystalline. Some very small cavities exist in the mass, in which the mineral has crystallized out in minute octahedral forms. Colour of massive mineral, dull bluish-grey, opaque; crystals greyish, with violet tinge, and transparent. Contains an admixture of feldspar. Sp. G. 3.56.

PLEONASTE.

Pleonaste occurs more or less plentifully with zircons and sapphires, at Apple Tree Gully, near Inverell. At Swamp Oak Creek, in the Inverell District, and about Paradise Creek (County Gough). At the zircon locality, on road from Glen Innes to Inverell, and among the pebbles in the beds of the Clairvaux and Furracabad Creeks, near Glen Innes. Also on south side of, and one quarter of a mile from the crossing of the Severn River, on road from Emmaville to Inverell. Generally occurs in broken fragments, irregularly shaped, rough, or waterworn and smooth; pieces 60 to 70 grains, common. Occasionally in tolerably perfect crystals. Black, opaque, exterior dull, but newly broken surfaces very lustrous. Fracture conchoidal, tough. Sp. G. 3.91, hardness over 8, scratches topaz.

VESUVIANITE (Idocrase).

Near crossing, and on eastern side of Ironbarks Creek, on New Road from Barraba to Bundarra (N.E.), in minute yellowish crystals, lining cavities in massive garnet. Crystals, transparent

to translucent; too small to admit of Sp. G. being taken, but aggregates from druses gave Sp. G. 3.19. Brittle, easily fusible to a blebby glass. The crystals have more complicated terminations than those from Bowling Alley Point* (see figure 12). The massive garnet referred to constitutes a large vein in the serpentine rocks of the locality.

RHODOCHROSITE (Mn Fe CO_3).

At Webb's Lode Silver Mine, near Emmaville (N.E.), in leafy and granular aggregations, at times two inches in area; also in small globular forms, seldom larger than an ordinary pin-head. In veins and small drusy cavities in the lode stuff; associated with and often seated upon crystals of quartz, and more rarely on crystals of galena, blende, tetrahedrite, lollingite, mispickel or fluorspar. Colour, pale nankin-yellow to brownish-yellow. Hardness about 3. Effervesces with HCl, and reacts for iron and manganese. Not very plentiful. The mineral veins of this locality are in hard splintery jointed argillaceous slates, which are in some places very much altered.

SIDERITE.

At Big Plain, on road from Inverell to Warialda, lining cavities in basalt, from the Government Well. In rhombic crystals with curved faces; crystals small, not more than $\frac{1}{8}$ inch square. Colour, yellowish-brown, reddish-brown, grey; opaque, but thin splinters transparent. BB. decrepitates, does not fuse, but becomes black and strongly magnetic. In fine powder effervesces with warm HCl. With borax and microcosmic salt dissolves slowly, giving an iron reaction only; with soda on platinum foil, trace of manganese. A globular form of this mineral (Spherosiderite) is present with the crystalline variety, and occurs in masses half-an-inch across; some of the spheroids have a radiated structure, but are often composed of concentric coatings. Spherosiderite also occurs in basalt in the Emmaville District. BB. and with reagents, behaves same as siderite.

CALCITE.

Deposits of calcite are common in the limestone formations, which extend with few breaks, from the Isis River, thirty miles south of Nundle gold-field, to Bingera, sixty miles in a northerly direction from Tamworth. Often in concentric aggregations or in stalactitic forms, also compact and cleavable. Colour, reddish, brownish, grey, nearly white. Translucent to opaque; not transparent.

* See Proceedings Royal Society, N.S.W., 1884, Vol. xviii.

At Tamba Springs, Liverpool Plains District, in veins and deposits in basaltic rocks. Massive, cleavable, no crystals observed. Brownish, yellowish, to colourless. The latter variety (Iceland spar) often in pieces two or three inches in diameter.

At Dangar's Gully, Nundle, in rhombic crystals in cavities in nodules of magnesian rock. The crystals often arranged in groups of three, and then presenting the form of a nail-head; also in rosette forms, from the grouping of several individuals. Colour, pale green to greyish. Translucent, gives strong iron reaction with reagents.

At Ben Lomond (N.E.), crystallized in cavities in basalt, with zeolites. Reddish, yellowish, colourless; mostly transparent, some opaque. Figures 3, 4, 5 are forms of crystals from this locality.

ARAGONITE.

Three miles north-east from the Big Plain Hotel, on road from Inverell to Warialda, in nodules in basaltic rocks. The nodular masses have a radiated structure, and are at times as much as twelve inches in diameter, generally whitish and translucent or opaque, but some transparent, with a pinkish tinge.

At Swan Vale, on road from Glen Innes to Inverell, one mile north from Swan Vale Post Office, in basaltic rocks, often in nodules, three inches in diameter, some radiated, but most compact and tough. Colour, greyish to nearly white; translucent.

Aragonite occurs in radiated transparent yellowish masses in several localities on the Myall Creek Estate, near Bingera.

NATROLITE (Mesotype).

At Ben Lomond (N.E.), with crystals of calcite, chabazite, and analcite, in radiated or incrusting tufts of delicate acicular crystals, in cavities in vesicular basalt. Colour, snow-white in mass, but individual crystals are really colourless.

At the Caves, five miles S.E. from the Swan Vale Post Office before mentioned, in rocks similar to those of the Ben Lomond localities; very plentiful, in acicular crystals, radiated and incrusting, transparent; aggregates appear snow-white.

Two miles west from Elsmore, on bank of the Macintyre River, near Inverell Road, in basalt. Compact, radiated, white, opaque.

HEULANDITE.

At Werris Creek, Great Northern Railway, near station house, crystallized in cavities in trappean or basaltic rocks; associated with stilbite. Crystals small, not more than $\frac{1}{4}$ inch in length; rare. Colour, pale yellowish white, transparent.

CHABAZITE.

At Ben Lomond (N.E.), in rhombic crystals (like figure 6) in cavities in amygdaloidal basalt, with other zeolites and calcite. Colourless and transparent when moist, usually white and opaque when dry. Occurs with other zeolites in the basalts about Emmaville. Phacolite is found in isolated crystals, in basalt, near the bridge at Inverell; translucent, friable (in forms like figure 7).

ANALCITE.

At Ben Lomond (N.E.), in trapezohedra grouped together in druses, or lining the walls of cavities in basalt. Crystals generally very perfect. Colourless, sometimes massive and opaque. Occurs also in the vesicular basalts of the Enimaville District.

LAUMONTITE.

Fifteen miles from Tamworth, in Old Goonoo Goonoo Creek, a quarter-of-a-mile above crossing of the road to Thos. Blevin's farm, in vein in fossiliferous rocks. The vein is about two inches in width. Colour, creamy tinted, opaque, pulverulent, very few crystals. Also two miles from James Swain's farm, seven miles S.E. from Carroll (Liverpool Plains), in veins in calcareous slates with stilbite and calcite; creamy white, opaque, good crystals though small.

At Werris Creek, crystallized; in small veins with stilbite in trap rocks (forms like figure 11). Crystals not common, usually amorphous.

STILBITE.

At Werris Creek in nodular deposits, and in crystals in amygdaloid, also in veins, associated with, and often enclosing, white opaque calcite. Crystals like figure 10 but small, not more than $\frac{1}{8}$ inch in length. The nodules exhibit a very perfect cleavage, and a pearly lustre. Colour, pale flesh red, to yellowish white, and nearly colourless. Transparent in thin laminae. Some of the uncrystallized mineral may be heulandite.

Near James Swain's selection, seven miles S.E. from Carroll (Liverpool Plains), in veins, near rocks containing marine fossils. Often inclosing nodular masses of white calcite. Crystals small.

At Walcha Road, Great Northern Railway, near railway station, in veins in decomposing granite. Crystals radiately compacted, but often with free terminations. Colour, pale buff, greyish, or nearly white translucent or opaque, pearly lustre, friable; common.

ON A SIMPLE PLAN OF EASING RAILWAY CURVES.

(One Plate.)

BY WALTER SHELLSHEAR, Assoc. M. Inst., C.E.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

ALTHOUGH universally admitted that it is a desirable thing to ease off the junction of the straight and curved portion of railways, also to ease off the junction of two reversed curves by a gradual increase of curvation, yet hitherto, with few exceptions, little has been done by English engineers when setting out railways, in the way of putting this into practice.

The object of this paper is to bring under attention a simple plan by which this can be done, without adding materially to the work of the surveyor, or overtaxing his brains with obtuse formula.

Of all curves the circle is most easily set out in the field, and for this reason, no doubt, the more complicated elastic curves have with few exceptions been carefully avoided. The circle being the easiest curve to set out, it will no doubt continue to be the one generally used, and if supplemented by a short curve of adjustment where it joins the straight line, the circle leaves little to be desired in the way of suitability.

Froude's method of easing curves, as published in Rankine's "Civil Engineering," although sound in principle, is somewhat tedious in application.

The problem that is required to be solved, is to find a curve which deviates from the point of zero curvature by a perfectly gradual increase curvature, and to see how such a curve can be applied to ordinary circular curves.

The cubic parabola is a curve which meets our requirements, as it deviates from the point of zero curvature by a perfectly gradual increase of curvature, and for a small portion of the curve the curvature is small, and is proportional to the distance from the point of zero curvature.

Now as the curvature in the cubic parabola deviates from the point of zero curvature by a perfectly gradual increase of curvature, it follows that at some point in the curve its radius of curvature is equal to the radius of a circle of any particular radius, and that it can therefore be so located that it will make a perfectly gradual curve of transition from the straight line to the circle.

The problem that has to be solved, is to so locate the circle and the cubic parabola, that at the point where they have an equal radius of curvature, they may have a common tangent.

THEORETICAL INVESTIGATION.

For the following investigation of the properties of the cubic parabola, as applied to transition curves, the author is indebted to Professor James Thompson, of the Glasgow University.

Definition :—The cubic parabola is a plain curve, which deviates from the point of zero curvature by a perfectly gradual increase of curvature, and for a small portion of the curve the curvature is small, and is approximately proportional to the distance from the point of zero curvature.

The equation of the cubic parabola is $y = mx^3$ where m is a constant numeric, where the axis of x is tangential at the point of inflection.

Fig. 1.

Definition :—The rise per unit of length = steepness.

To find the steepness of a curve at any point :—Let O be the point of inflection, and YY the axis of Y , and XX the axis of X .

Fig. 2.

$$\begin{aligned} A B &= dx \\ B P_2 - A P_1 &= dy \\ (y_1 + dy) &= y_2 \end{aligned}$$

To express the steepness of the curve at any point it is expressed as the tangent of the inclination at that point.

Let θ = angle of inclination to OX at P_1 , then $\tan \theta$ = steepness of the curve at P_1 , but steepness at the point P_2 , $= \frac{dy}{dx}$.
 $\therefore \frac{dy}{dx} = \tan \theta$ where $\frac{dy}{dx}$ is very small.

Fig. 3.

Let AE be a unit of length, and let the angle DAE be θ , then $DE = \tan \theta$.

Let AB be very small and be represented by dx , and let BC be very small and be represented by dy .

$$\text{Then } \frac{BC}{AB} = \tan \theta = \frac{dy}{dx}$$

In the cubic parabola we have :—

$$y = mx^3, \text{ (in general).}$$

$$y_1 = mx_1^3, \text{ when } y_1, \text{ and } x_1, \text{ are particular values of } x \text{ and } y.$$

Also $y_2 = mx_2^2$ when x_2 and y_2 are particular values of x and y .

If $y_2 - y_1 = dy$, and $x_2 - x_1 = dx$

Then $y_2 = m(x_1 + dx)^2$.

$$\therefore y_2 = m \{x_1^2 + 3x_1^2 dx + 3x_1(dx)^2 + (dx)^2\} = mx_1^2 + 3mx_1^2 dx + 3mx_1(dx)^2 + m(dx)^2$$

But $y_1 = mx_1^2$, and $dy = y_2 - y_1$,

$$\therefore dy = 3mx_1^2 dx + 3mx_1(dx)^2 + m(dx)^2$$

$$\therefore \frac{dy}{dx} = 3mx_1^2 + 3mx_1 dx + m(dx)^2.$$

When $\frac{dy}{dx}$ are very small they become equal to $3mx_1^2$, but

$$\tan \theta = \frac{dy}{dx} = 3mx_1^2.$$

The tangents of small angles are (approximately equal) \doteq to the angles in radian (circular) measure. $\therefore \theta \doteq 3mx_1^2$.

Fig. 4.

$$\frac{dy}{dx} = 3mx_1^2$$

$$\tan \theta = 3mx_1^2$$

$$\theta \doteq 3mx_1^2 \text{ (when } \theta \text{ is small).}$$

Let ds = a small increase of length on curve, for length dx on ordinate.

When the angle is small we may use ds , or dx , at discretion, for they are \doteq to each other.

Let the curvature at P_1P_2 be denoted by γ (gamma).

$$\text{Curvature} = \gamma = \text{change of angle of inclination} = \frac{d\theta}{dx} \doteq \frac{d\theta}{ds}$$

Required the value of $\frac{d\theta}{dx}$ which will give the curvature γ .

$$\theta_1 = 3mx_1^2$$

$$\theta_2 = 3mx_2^2$$

$$\theta_2 = 3m(x_1 + dx)^2,$$

$$\theta_2 = 3m \{x_1^2 + 2x_1 dx + (dx)^2\}$$

$$\theta_2 = 3mx_1^2 + 6mx_1 dx + 3m(dx)^2$$

$$(\theta_2 - \theta_1 = d\theta) \therefore d\theta = 6mx_1 dx + 3m(dx)^2$$

$$\therefore \frac{d\theta}{dx} = 6mx_1 + 3m dx$$

But when dx is very small, $3 m dx$ vanishes and $\frac{d\theta}{dx} = 6 mx_1$ for curvature at x_1 .

$$\text{In general } \frac{d\theta}{dx} = 6 mx$$

But $\frac{d\theta}{dx}$ is equal to curvature = γ .

$$\therefore \gamma = 6 mx.$$

To apply the cubic parabola to easing the transition of circular curves.

$$y = mx^3$$

$$\gamma = 6 mx$$

$$R = \frac{1}{6 mx}$$

$$\frac{dy}{dx} = \tan \theta = 3 mx^2 = \text{steepness at the point } x.$$

To adjust the circle to the curve.

Fig. 5.

Let R = radius of curvature of circle.

X and Y particular values of x and y .

Let P be the point of contact.

$$\left. \begin{array}{l} TP = Y \\ OT = X \end{array} \right\} = \text{values of } x \text{ and } y \text{ at point of contact } P.$$

$$\text{Radius of curvature at } P = R = \frac{1}{6 mX}$$

X = length of curve of adjustment.

$$6 mX = \frac{1}{R} \quad m \text{ is a constant.}$$

$$\therefore m = \frac{1}{6 XR}$$

\therefore the curvature is determined.

Proposition:—To find the value of $(Y = TP)$ in terms of $(X = OT)$ and also in terms of R .

$$Y = mX^3.$$

$$m = \frac{1}{6 XR}$$

$$\therefore Y = \frac{X^3}{6 XR}$$

$$\therefore Y = \frac{X^2}{6 R}$$

$$\therefore Y = \frac{4}{6} \left(\frac{X}{2}\right)^2 \frac{1}{R}$$

Let the tangent offset be represented by $\tau = UP$.

$$\tau \times (2R - \tau) = \left(\frac{X}{2}\right)^2 \text{ (Euclid, Book iii, Prop. 35)}$$

When τ is very small. $\tau \times (2R - \tau) \doteq \tau \times 2R$

$$\therefore \tau \times 2R \doteq \left(\frac{X}{2}\right)^2$$

$$\text{Or } \tau \doteq \frac{\left(\frac{X}{2}\right)^2}{2R}$$

$$\tau \doteq \frac{3}{6} \left(\frac{X}{2}\right)^2 \times \frac{1}{R}$$

$$\doteq \frac{3 \left(\frac{X}{2}\right)^2}{6R}$$

$$\text{But } Y = 4 \frac{\left(\frac{X}{2}\right)^2}{6R}$$

$$\therefore Y = \frac{4}{3} \tau \text{ where } \tau \text{ is small.}$$

Proposition :—To find the position of the circle.

$$\frac{dy}{dx} = 3mx^2$$

$$\frac{dy}{dx} = 3mX^2. \text{ (at } P \text{)}$$

$$\text{But } m = \frac{1}{6RX}$$

$$\therefore \frac{dy}{dx} \text{ at } P = \frac{3X^2}{6RX} = \frac{3X}{6R} = \frac{X}{2R}$$

$$\frac{PL}{LC} = \frac{dy}{dx} \text{ or } \frac{PL}{R} \doteq \frac{dy}{dx} \text{ or } \frac{PL}{R} = \frac{X}{2R}$$

$$\therefore PL = \frac{X}{2}$$

$$OQ = TP$$

To show that $MN = \frac{1}{4} TP = \frac{1}{4} Y = h$

Let x_1 and y_1 be co-ordinates for points in circle for origin O ;
and let $MN = h$

$$\text{But } y_1 \doteq h + \frac{\left(x_1 - \frac{X}{2}\right)^2}{2R}$$

$$Y = h + \frac{\left(\frac{1}{2} X\right)^2}{2R} \text{ but } X^2 = 6RY$$

∴ To get h in terms of Y by eliminating X

$$\begin{aligned}\text{We get } Y &= h + \frac{6RY}{4} \times \frac{1}{2R} \\ &= h + \frac{3}{4} Y\end{aligned}$$

$$\therefore h = \frac{1}{4} Y \text{ but } h = MN \therefore Y = 4 MN$$

Therefore the distance between the real auxiliary tangent
 $= h = \frac{1}{4} Y$.

PRACTICAL APPLICATION OF THE CUBIC PARABOLA FOR EASING RAILWAY CURVES.

From the above investigation we have got the following results :—

That from the origin of the curve to a vertical line drawn through the centre of the circle, is half the length of the curve of adjustment. Also that the distance the circle has to be set in from the parallel tangent, is equal to one-third of the tangent offset at the point of junction of the circle and the cubic parabola, and is also equal to one-fourth of the ordinate at the same point.

Perhaps the best way of illustrating the matter, is to give one or two practical examples.

Example I.

It is desired to ease a curve of 10 chains radius, through a length of 2 chains.

The first point to be determined is at what parallel distance from the straight line will the tangent to the circle be.

$$\text{We have } X = 2 \text{ chains}$$

$$R = 10 \text{ chains}$$

$$m = \frac{1}{6XR}$$

$$\therefore m = \frac{1}{6 \times 2 \times 10}$$

$$= \frac{1}{120}$$

$$\text{Again we have } y = m\alpha^3$$

$$= \frac{1}{120} \times 8$$

$$= \frac{2}{30}$$

$$\text{And } h = \frac{1}{4} Y$$

$$\therefore h = \frac{1}{60}$$

Therefore the distance of the straight line from the tangent to the circle is $\frac{1}{8}$ of a chain, or 1.1 feet, or 13.2 inches, and the offset at $Y = 4.4$ feet, or 52.8 inches.

The other points in the curve have ordinates proportional to the cube of the distance from the origin, and to facilitate the calculation of these offsets a table will be found in the Appendix, where these proportions have been calculated out; also a table giving offsets for all curves from 5 to 20 chains radius eased through a length of 2 chains.

Example II.

It is desired to ease a curve of 4 chains radius through a length of 1 chain.

To find the distance of the tangent to the circle from the straight line

We have $X = 1$ chain

$R = 4$ chains

$$\begin{aligned} m &= \frac{1}{6XR} \\ &= \frac{1}{6 \times 1 \times 4} \\ &= \frac{1}{24} \end{aligned}$$

Again we have $y = mx^3$

$$\begin{aligned} &= \frac{1}{24} \times 1^3 \\ &= \frac{1}{24} \end{aligned}$$

$$h = \frac{1}{4} Y = \frac{1}{24} \times \frac{1}{4} = \frac{1}{96}$$

Therefore the distance of the straight line from the tangent to the circle is $\frac{1}{96}$ of a chain, or .68 of a foot, or 8.16 inches, and the offset at $Y = 2.72$ feet, or 32.64 inches. Other points in the curve can be calculated by the attached table of proportions.

In conclusion, although there may not be much that is original in this paper, the author is not aware that any tables giving the practical application of this system have ever been published before, and he hopes that they may be found useful to the railway engineer.

APPENDIX.

Table giving proportion of offsets for curve of transition, when 0 is the origin of the curve, and the offset at the point of contact = 1.

FOR 16 POINTS ON THE CURVE.

Origin.								Centre.									P't. of Contact.
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0	·00024	·00195	·00359	·01562	·03061	·05273	·06374	·125	·17797	·24414	·32405	·42187	·53637	·66992	·82397	1·0	

FOR 8 POINTS ON THE CURVE.

Origin.				Centre.				Point of Contact.
0	1	2	3	4	5	6	7	8
0	·00195	·01562	·05273	·125	·24414	·42187	·66992	1·0

FOR 4 POINTS ON THE CURVE.

Origin.		Centre.		Point of Contact.
0	1	2	3	4
0	·01562	·125	·42187	1·0

Table of offsets and distances of parallel tangents for curves from 5 to 20 chains radius, eased through a length of 2 chains, giving 8 offsets for each curve.

R. Radius of Curve.	h. Distance of Parallel Tangent.	Origin.	Centre of Curve = $\frac{h}{2}$						Point of Contact = Y.	Tangent Offset = τ .	
			1	2	3	4	5	6	7	8	
Chains.	In.		In.	In.	In.	In.	In.	In.	In.	In.	In.
5	26.6	0	.2	1.6	5.5	13.3	25.7	44.6	70.6	105.4	79.2
6	22.0	0	.17	1.4	4.6	11.0	21.5	37.1	58.9	88.0	66.0
7	18.8	0	.15	1.18	4.0	9.4	18.4	31.8	50.5	75.4	56.5
8	16.5	0	.13	1.03	3.5	8.2	16.1	27.8	44.2	66.0	49.5
9	14.6	0	.11	.91	3.1	7.3	14.3	24.7	39.2	58.5	43.9
10	13.3	0	.10	.82	2.8	6.6	12.9	22.3	35.4	52.8	39.6
11	12.0	0	.09	.75	2.5	6.0	11.7	20.2	32.2	48.0	35.9
12	11.0	0	.08	.69	2.3	5.5	10.7	18.6	29.5	44.0	33.0
13	10.1	0	.08	.63	2.1	5.0	9.9	17.1	27.2	40.6	30.5
14	9.4	0	.07	.59	2.0	4.7	9.2	15.9	25.2	37.7	28.3
15	8.8	0	.07	.55	1.8	4.4	8.6	14.8	23.6	35.2	26.4
16	8.2	0	.06	.51	1.7	4.1	8.0	13.9	22.0	32.9	24.7
17	7.7	0	.06	.48	1.6	3.8	7.6	13.1	20.8	31.0	23.3
18	7.3	0	.06	.46	1.5	3.6	7.1	12.4	19.6	29.3	22.0
19	6.9	0	.05	.43	1.5	3.4	6.8	11.7	18.6	27.7	20.8
20	6.6	0	.05	.41	1.4	3.3	6.4	11.1	17.7	26.4	19.8

$$Y = mX^2. \quad m = \frac{1}{6} \frac{1}{XR}. \quad h = \frac{1}{4} Y = \frac{1}{3} \tau. \quad Y = \frac{4}{3} \tau.$$

τ = Tangent offset.

$X = 2$ chains in above table.

WEDNESDAY, 6th JUNE, 1888.

Sir ALFRED ROBERTS, President, in the Chair.

Twenty-five members were present.

The minutes of the last meeting were read and confirmed.

The certificates of two candidates were read for the third time, of three for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Blaxland, Walter, F.R.C.S., *Eng.*, &c., Sydney.

Clubbe, C. P. B., L.R.C.P., *Lond.*, M.R.C.S., *Eng.*, Randwick.

The Chairman announced that the Council had awarded the Society's Medal and money prize of £25 to the Rev. J. E. Tenison-Woods, F.L.S., F.G.S., for his paper upon "The Anatomy and Life-history of Mollusca peculiar to Australia."

He also stated that Mr. Robert Etheridge, Government Palæontologist, being now a resident of Sydney, had retired from his Corresponding Membership, and become an Ordinary Member of the Society.

The following letters were read from the Rev. J. E. Tenison-Woods, F.L.S., &c., acknowledging the award of the Society's Medal and money prize; and from Hyde Clarke, Esq., London, a Corresponding Member of the Society :—

533 Elizabeth Street, Sydney,
31st May, 1888.

F. B. Kyngdon, Esq., Hon. Sec. Royal Society of N.S.W.

Sir,—I have the honor to acknowledge receipt of your letter conveying to me the agreeable intelligence that the Council of the Society had awarded to me the prize and the Society's Medal for my essay on "The Anatomy and Life-history of Mollusca peculiar to Australia." I have also to acknowledge a cheque for £25, being the amount of the Society's prize.

Will you kindly convey to the Council my sincere thanks for the honor thus done me, and assure them that the Medal will be treasured by me and the award considered distinguished encouragement to research in biology.

I beg to enclose you a cheque for the sum of five pounds (£5) as a contribution to the building fund of the Society, which the Council will do me a favor by accepting.

I will revise the manuscript as soon as possible, and will, with the permission of the Council, add some interesting observations which I have been able to make since the essay was first sent in. I will return it ready for the press in a few days.

I have the honor to be, Sir,

Yours very faithfully,

J. E. TENISON-WOODS.

32 St. George's Square, S.W.,

London, 18th April, 1888.

Dear Sir,—I have received the 20th Volume of the *Journal of the Royal Society*, and Part ii. of Vol. xxi. These I beg to acknowledge with sincere thanks.

I note with interest the paper of Rev. G. Pratt on the "Comparison of Dialects of E. & W. Polynesia and Australia, &c." All such matter tends to illustrate an obscure subject. I may, however, repeat that the analogies of Australian as they belong to the general body of language, so must they be more widely illustrated, as I shewed in my paper before the Royal Society.

As this is the year of your Jubilee, I beg to congratulate the Society, and to regret I can take no active part in its celebration.

To most the hundred years must seem a very remote epoch. To me it is not, for in my early years the generation which had known Cook's discoveries and taken part in the establishment of New South Wales still remained. To me its traditions are fresh, and in nearly seventy years I have watched with interest the later and wonderful growth of your communities.

There are some of us still alive who saw Cook's ship lying in the Thames, and his men in Greenwich Hospital. It is therefore a matter to me of intense gratification to see taking a great place in the regions of civilization, a great Continent—which I saw figuring in the maps as *Terra Australis Incognita*—lost to the world for so many ages.

Not least among marvellous events is the opening to us and to you of the new route across the Pacific Ocean to Vancouver. Noolka, as it was then called, was to me no unfamiliar name. Some of our Australian friends have been born to the full birthright of all such glories, but to myself and those who remember their dim and doubtful beginnings, and the arduous labour of the pioneers by whom success has been achieved, the history of Australian progress has been among the wonders of our age.

Yours faithfully,

HYDE CLARKE,
Corr. Member Royal Society of N.S.W.

To Prof. A. Liversidge, M.A., F.R.S.,

Hon. Secretary Royal Society of N.S.W.

The following papers were read :—

1. "Notes on some Minerals and Mineral Localities in the Northern Districts of New South Wales," by Mr. D. A. Porter, Tamworth.

2. "Forest Destruction in New South Wales, and its effect on the flow of water in water-courses and on the rainfall," by Mr. W. E. Abbott, Wingen.

The discussion upon this paper was adjourned to a future meeting.

3. "On the Increasing Magnitude of Eta Argus," by Mr. H. C. Russell, B.A., F.R.S.

Questions were asked by Messrs. Trevor Jones, E. A. Baker, and J. U. C. Colyer, to which Mr. Russell replied.

4. "On a Simple Plan of Easing Railway Curves," by Mr. Walter Shellshear, Assoc. M. Inst., C.E.

A discussion followed, in which Messrs. F. B. Gipps, J. Trevor Jones, and Professor Warren took part.

5. "Indigenous Australian Forage Plants (exclusive of grasses) including Plants injurious to Stock," by Mr. J. H. Maiden, F.L.S.

The thanks of the Society were conveyed to the various authors for their valuable papers.

The following donations received during the month of May were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF MAY, 1888.

- BATAVIA**—Kon. Natuurkundige Vereeniging in Nederl Indië
Natuurkundig Tijdschrift voor Nederlandsch-Indië,
Deel xlvii., 1887. *The Society.*
- BOSTON**—American Academy of Arts and Sciences. Pro-
ceedings, New Series, Vol. xiv., Whole Series, Vol.
xxii., Part 2, 1887. *The Academy.*
- BUCHAREST**—Institutul Meteorologic al Romăniei. Annales,
Tome ii., 1886. *The Institute.*
- CALCUTTA**—Asiatic Society of Bengal. Journal, Vol. lvi.,
Part i., Nos. 2 & 3; Part ii., Nos. 2 & 3, 1887.
Proceedings, Nos. 9 & 10, 1887; No. 1, 1888. *The Society.*
- Geological Survey of India. Records, Vol. xxi., Part 1,
1888. *The Director.*
- CAMBRIDGE (MASS.)**—Cambridge Entomological Club.
Psyche, Vol. v., Nos. 143 & 144, 1888. *The Club.*
- Museum of Comparative Zoölogy at Harvard College.
Bulletin, Vol. xiii., Nos. 7 & 8, 1888; Vol. xvi.,
No. 1. (Geological Series, Vol. ii.) 1888. *The Museum.*
- DRESDEN**—K. Sächsische Statistische Bureau. Zeitschrift,
xxxiii., Jahrgang, 1887, Heft 1 & 2. *The Bureau.*
- EDINBURGH**—Botanical Society. Transactions and Proceed-
ings, Vol. xvii., Part 1, 1887. *The Society.*
- Royal Scottish Geographical Society. *The Scottish
Geographical Magazine*, Vol. iv., No. 3, 1888. „
- FLORENCE**—Società Africana d' Italia, Sezione Fiorentina.
Bullettino, Vol. iv., Fasc. 1 & 2, 1888. „
- FRANKFURT A.M.**—Senckenbergische Naturforschende
Gesellschaft. Abhandlungen, Band xv., Heft 1,
1887. „
- HAMBURG**—Deutsche Meteorologische Gesellschaft. Meteorolo-
gische Zeitschrift, Heft 4, April, 1888. „
- HOBART**—Royal Society of Tasmania. Abstract of Pro-
ceedings, April 23, 1888. „

- IOWA CITY**—Iowa Weather Service. A Few Facts about the Iowa Weather Service. A Few Plain Words: Administration of the State University of Iowa. Biennial (Fifth) Report of the Central Station, 1887. Climate of Southern Russia and Iowa Compared. Flag Signals of the Signal Service. The Iowa Weather Service, and How it is Supported. *The Director.*
- LONDON**—Royal Astronomical Society. Memoirs, Vol. xlix., Part 1, 1888. Monthly Notices, Vol. xlviii., No. 4, 1888. *The Society.*
- Royal Geographical Society. Proceedings (New Monthly Series), Vol. x., No. 3, 1888. „
- Linnean Society. Journal—Botany, Vol. xxiv., No. 162, 1888. „
- Meteorological Office. Meteorological Observations at Stations of the Second Order for the year 1883. *Official No. 73.* Synchronous Weather Charts of the North Atlantic, Part iii. From 15th February to 24th May, 1883. *Official No. 71.* *The Office.*
- Mineralogical Society. The Mineralogical Magazine and Journal, Vol. vii., No. 35, 1887. *The Society.*
- Pharmaceutical Society of Great Britain. Journal and Transactions, Third Series, Part 212, Feb., 1888. „
- MELBOURNE**—Field Naturalists' Club of Victoria. *The Victorian Naturalist*, Vol. v., No. 1, 1888. *The Club.*
- MEXICO**—Sociedad Científica "Antonio Alzate." Memorias, Tome i., Cuaderno Núm. 8, 1888. Nouvelles Tables de Logarithmes La Circonférence étant prise pour unité (Texte en Français) par J. de Mendizabal Tamborrel. *The Society.*
- MONTREAL**—Natural History Society of Montreal. *The Canadian Record of Science*, Vol. iii., No. 2, 1888. „
- MOSCOW**—Société Impériale des Naturalistes de Moscow. Bulletin, No. 1, 1898, and Supplement to Série, 2, Tome i. „
- NEWCASTLE-UPON-TYNE**—North of England Institute of Mining and Mechanical Engineers. Transactions, Vol. xxxvii., Part 2, 1888. *The Institute.*
- NEW YORK**—American Chemical Society. Journal, Vol. ix., No. 10, 1887. *The Society.*
- Journal of Comparative Medicine and Surgery.* Vol. ix., No. 2, 1888. *The Editor.*
- New York Academy of Sciences. Transactions, Vol. iv., 1884-85. *The Academy.*
- New York Microscopical Society. Journal, Vol. iv., No. 2, 1888. *The Society.*
- Science.* Vol. xi., Nos. 266-273, 9th March to 27th April, 1888. *The Editor.*

- PARIS**—Société de Biologie. Comptes Rendus, Tome v., Nos. 11-15, 23rd March to 27th April, 1888. *The Society.*
 Société de Géographie. Compte Rendu, Nos. 4 & 5, 1888. "
 Société Française de Minéralogie. Bulletin, Tome xi., No. 2, 1888. "
 Société Française de Physique. Réunion, du Vendredi, 20th Avril, 1888. "
 Société Zoologique de France. Bulletin, Tome xiii., No. 2, 1888. "
- PHILADELPHIA**—Academy of Natural Sciences. Proceedings, Part ii., 1887. *The Academy.*
 American Philosophical Society. Proceedings, Vol. xxiv., No. 126, 1887. *The Society.*
 Franklin Institute. Journal, Vol. cxxv., No. 748, 1888. *The Institute.*
 Second Geological Survey of Pennsylvania. Annual Report, 1886, Part i., Pittsburgh Coal Region; Part ii., Oil and Gas Region. *The Board of Commissioners.*
- PISA**—Società Toscana di Scienze Naturali. Processi Verbalì, Vol. vi., pp. 37-72. *The Society.*
- RIO DE JANEIRO**—Imperial Observatorio. Annuario, 1885, 1886, 1887, Revista, Anno iii., No. 2, 1888. *The Observatory.*
- ROME**—Accademia Pontificia de Nuovi Lincei. Atti, Anno xxxviii., Sessione 5a, 6a, 7a, 1885. *The Academy.*
 Biblioteca Nazionale Centrale Vittorio Emanuele di Roma. Bollettino delle Opere Moderne Straniere, Vol. ii., Nos. 2-6, 1887. *The Library.*
 R. Comitato Geologico d'Italia. Bollettino, Vol. xix., Serie 2; Vol. ix., Nos. 1 & 2, 1888. *The Committee.*
 Società Geografica Italiana. Bollettino, Serie 3, Vol. i., Fasc. 3 & 4, 1888. *The Society.*
- SAINT ETIENNE**—Société de l'Industrie Minérale. Comptes Rendus Mensuels, Février, 1888. *The Society.*
- SAN FRANCISCO**—California State Mining Bureau. Seventh Annual Report of the State Mineralogist for the year ending October 1, 1887. *The Bureau.*
- SYDNEY**—Linnean Society of New South Wales. Proceedings, Second Series, Vol. iii., Part 1, 1888. *The Society.*
- TRIESTE**—Osservatorio Marittimo di Trieste. Rapporto Annuale per l'anno 1885, Vol. ii. *The Observatory.*
- VIENNA**—K. K. Geologische Reichsanstalt. Jahrbuch, Band xxxvii., Heft 1, 1887. Verhandlungen, Nos. 2 to 8, 1887. *The "Reichsanstalt."*
 K. K. Zoologisch-botanische Gesellschaft in Wien. Verhandlungen, Band, xxxii., Quartal 1 & 2, 1887. *The Society.*
- WASHINGTON**—Chief of Engineers U. S. Army. Annual Report for the year 1886, Parts i., ii. & iii. *The Chief of Engineers.*

AN IMPROVEMENT IN ANEMOMETERS.

BY H. C. RUSSELL, B.A., F.R.S.

[*Read before the Royal Society of N.S.W., July 4, 1888.*]

ONE of the most interesting and practically important questions in relation to wind, is what is its maximum velocity or pressure, for the one depends on the other. I need hardly say that many attempts have been made to devise instruments capable of answering that question. It has been generally admitted that existing Anemometers using Robinson's Cup are unequal to the task, because a gust lasts but a few seconds, often not more than five or six, and the recording parts made to register an hour's work on $\frac{1}{2}$ an inch or 1 inch of paper will not shew satisfactorily a gust lasting 10 seconds, that is $\frac{1}{360}$ part of an hour; or, in other words, if one could measure such a gust, it would be $\frac{1}{360}$ part of an inch on the paper, and the smallest error in measuring becomes so magnified when the measured velocity in 10 seconds is converted into velocity per hour, that results are rendered very uncertain. Pressure plates have also been tried in every form, but it is found the results are not satisfactory, because when a gust of wind coming along at a velocity of say 50 miles an hour strikes a pressure plate, it has just the same effect upon it as if it were a hammer striking it a blow: it sets it into rapid motion which by acquired momentum carries it much further than it ought to do. Now Robinson's Cups are free from this defect, and although not without drawbacks, they are in my opinion the best means we have of recording gusts of wind. Of course the open cup, like the pressure plate, is struck by the advancing gust, but at the same moment the same gust strikes the back of the opposite cup and resists any tendency to run away, and it seemed to me that what was wanted was a means of recording with all possible accuracy, the interval of time which the cups took to run a given number of evolutions, and I have accomplished this by putting in a series of pins in the first wheel, so that they make an electrical contact on a light gold spring for every 10 revolutions of the cups. So far there is nothing new. Many Anemometers have been made to record by electrical contacts. The point that I think is new, is that these contacts are recorded on either of the astronomical chronographs, so that the interval between two contacts can be determined with certainty to within one-tenth of a second or even less. The intention is to use this method only

for very strong winds, the Observatory Anemometer has an ordinary scale of 1 inch of paper to the hour, which may be increased to 2 inches, and this is quite enough for all ordinary winds, and more than it is usual to have in Observatories. The new method is one that can at any moment be put into operation by turning an electrical key, and at all other times it is at rest, and costs nothing either in paper or battery force.

DISCUSSION.

Professor THRELFALL asked if it were possible to calculate wind pressure.

MR. RUSSELL :—Not satisfactorily, but a certain rule is generally adopted. There is no question perhaps which is more discussed nowadays as to what is the actual pressure of wind. All the attempts to record the pressure of the wind on any pressure plate have practically failed for several reasons: first, owing to the recoil of the wind that strikes the plate its surface is virtually extended, and gusts at a velocity of 60 or miles an hour or 100 feet in a second strike the plate as if it were struck a blow from a hammer. I have found in an ordinary north-easter, where the wind was not blowing more than 30 miles an hour, that some of the gusts would strike the plate, and make it appear that the velocity was 90 miles an hour, and I was so impressed with the uncertainty that I ceased to trust pressure plates. I think the system called Robinson's Cups is as accurate as any for measuring the velocity. They are subject to some small correction in some cases and not in others, and there is this to be said in their favour: if we measure by such a system as that, we are measuring by an apparatus that can be reproduced hereafter with certainty, and we at any rate get a measure on an uniform system, and if ultimately it is found that the ratio now assumed to exist between the cups and the velocity of the wind be proved incorrect, it nevertheless will be possible to apply the correct ratio to the observations which are now being made, as to the possibility of determining the pressure of the wind by other means. About 10 years since, a railway engine was blown right off the rails in America—a heavy freight engine, and the question as to what pressure of wind was required to blow it over was investigated, and it was found that nothing less than 95 lbs. to the square foot would have that effect; and there are many similar cases in which the wind has actually exerted pressures greatly in excess of what is often assumed to be its maximum.

MR. J. S. MITCHELL :—Many years ago in Tasmania I was very much interested with a very complete arrangement they had at the Observatory for measuring the strength of the wind and the rainfall, and I took myself to make one. I noticed that the

pressure plate for measuring the strength of the wind rested upon springs, so that when the wind blew upon the pressure plate against the springs, by a simple contrivance a pencil marked on the chronograph the strength of the wind and the exact time when it occurred. But it always appeared to me that these springs were not fitted with the mechanical appliances that should be applied to them, because we very well know that if we strike any substance resting upon springs, there is a kind of impulse given to it which scarcely measures the exact force of the blow. I do not know whether any other contrivance has been adopted for this Anemometer or not, but I had an idea at the time (I did not finish this Anemometer I was about to construct) that another contrivance would measure it better, and that was by having a chain weight attached to it. I would ask Mr. Russell what improvements have been introduced since the pressure plates rested on springs.

MR. RUSSELL :—A great many methods of supporting the plate have been tried, but the one most in favour is hanging the plate on four springs, thereby endeavouring to get rid of friction ; but all the methods are subject to the defect I pointed out, that these violent gusts come along and have the effect of striking the pressure plate like a hammer. It is quite recognised that it does not record the pressure of the wind exactly. Some of the effects of the pressure of the wind are almost incredible. I have an account of a tornado which passed through the bush near Cobar. It cut a narrow lane through the bush, breaking off short every tree in its path, some of them 18 inches in diameter ; shrubs were torn up by the roots, and the tops of large trees forced along the ground after they had fallen, so making grooves in the ground like a plough, and the circular motion of the wind could be seen in the arrangement of the fallen timber. If such a storm ever passes over Sydney there will be many wrecked houses. We know nothing of the velocity of the wind in these terrible tornados. Anemometers made light to record ordinary storms are broken directly by such violent winds, and we can only judge of the velocity by the force shewn in breaking great trees, destroying houses, &c.

HON. G. H. COX :—Can Mr. Russell give even a guess as to the enormous velocity of the wind to create such destruction as that ? I can remember many years ago where in a track for 20 miles through the bush the trees were twisted off. What would be the velocity of the wind to cause such enormous destruction as that ? I mean a velocity not only to turn over an engine but houses almost in the streets of the city.

MR. RUSSELL :—I am afraid I could not give a guess. We have records which shew that the wind must have exerted a

pressure of 95 pounds on the square foot, as just mentioned by me, in order to overturn a railway engine, and other instances of like kind; but it is more than probable that the force exerted by the wind in a tornado, which breaks off large trees 18 inches in diameter, is much greater, but it has never been measured.

Mr. MANN:—I was in a storm many years ago. I saw it coming up from the southward. I took refuge in my house. There was a large tree at the northerly end of the house. The cyclone twisted this tree and it fell to the southward. It fell over the house and smashed everything to the ground. I went to the door and got out. A quarter-of-a-mile off there was a camp of blackfellows. Their gunyahs were upset. The storm went on and twisted the head off one of the gigantic trees three or four feet in diameter, and the head of the tree which must have weighed 200 tons, was suspended in the air off the ground before it came to the ground.

The PRESIDENT:—We are much indebted to Mr. Russell for his paper and the interesting discussion it has evoked. As the time is going on, I will now call upon the Hon. Secretary to read the next paper. We are all sorry to feel that the author of this next paper is an invalid, and suffering from the injurious effects of his travels, and therefore unable to be present.

ON THE ANATOMY AND LIFE HISTORY OF MOLLUSCA PECULIAR TO AUSTRALIA.

[With Plates.]

BY REV. J. E. TENISON-WOODS, F.L.S., F.G.S.

[*Read before the Royal Society of N.S.W., July 4, 1888.*]

THE Mollusca of the Australian coast are sufficiently peculiar to entitle the region to be considered a geographical province. Yet it must be acknowledged that the distinction, though well marked in some respects, is not so peculiar or abnormal as in other sections of the Animal or Vegetable Kingdom. The exceptional characters of the land mammalia, for instance, are truly extraordinary, while of the flora it may be said that volumes have been written about it, and yet volumes must still be written ere the subject be fully unfolded. In the seas and in the rivers, in other departments of the Animal Kingdom multitudes of marvels meet us, all of so strikingly an anomalous kind, that Australia well deserves to be considered a Zoological region, singularly apart from the rest of

the World. As we descend in the scale of life, however, this character becomes less marked, and amongst the Mollusca, though still evident, it is not strikingly apparent.

If we examine into the question, as to what the peculiar features of the Australian Molluscan region are, we find them to consist:—

1. In the possession of a few remarkable genera which are not found in other parts of the World. These contain but few species for the most part.

2. In the possession of abnormal forms of genera which are found elsewhere.

3. In possessing living representatives of extinct fossil forms of Molluscan life, which have played an important part in the earth's former history. Australia has in several other sub-kingdoms remarkable instances of these "survivals" which may be said to be the specialty of its Zoology.

4. In the singular and unaccountable possession of genera and species, which are only known in provinces a great distance apart.

5. In the possession of extraordinary organs in a few instances, such as have been only known to a limited extent amongst Mollusca generally, though not confined to Australia. This peculiarity will be the subject of the inquiries and experiments recorded in this paper. It should, however, be borne in mind, that these organs may become less and less extraordinary as the animals elsewhere are more carefully and extensively studied.

Having pointed out the peculiarities, it must be added that they only affect the anatomy and life-history of Australian Mollusca to a very slight extent: that is to say, the dissections and life observations reveal nothing, or scarcely anything different from what is found amongst Mollusca elsewhere. Thus the dissection of our fresh-water *Unio*, or our salt-water oyster and sea mussel, show that they are, in all but the most trifling particulars, identical with similar animals in Europe. Or, again, a careful examination of the animals of our marine periwinkle or common garden slugs or snails gives us the same organs, disposed in the same manner as the familiar Mollusca of the same kind elsewhere. Our *Unio* has the same peculiarities of the cardiac region, with the outer gill distended with *Glochidia* or young Mollusks whose initiatory life-history is there unfolded before us. The buccal mass of our snails has the same arrangement of the protractor and retractor muscles; the Radula is of the same type, and we find precisely similar distinctions between the dental formula of the various genera. In the course of some years observation, anatomical and microscopical, and in observations on the habits of species, naturalists have come to the conclusion that nothing unusual in these directions is revealed to the observer in Australia. If any lines of investigation are open to the anatomist,

microscopist, or zoologist, they are such as are equally open to observers elsewhere. This at least is a fact of some interest. It is a negative result, yet requiring more extensive observation than any other path of discovery. I wish to record it here as one result of years of observation, pursued under what must be admitted were exceptional advantages. Having been in the midst of the living animals, and having visited in succession almost every part of the Australian and Tasmanian coasts, I have had ample means of ascertaining what are the facts of the case.

In recording the above conclusions, it must not of course be forgotten that there are exceptions to this uniformity, and these are of a singularly interesting kind. As an illustration of what is meant, let us take the instance of *Trigonia*, which, as most people are aware, is a "survival" in Australia of a few species of an almost extinct family, but one which played a most important part in far distant geological times. Now, when Prof. Huxley visited the Australian coast as Assistant Surgeon to the "Rattlesnake," in 1849, he made a special study of the animal of *Trigonia*, which had been previously described by Messrs. Quoy and Gaimard, but much too briefly. The result is published in the "Proceedings of the Zoological Society for 1849," p. 30, but reveals nothing of any great importance. Messrs. Quoy and Gaimard remark that the disposition of the mantle and the absence of tubes, show a resemblance to the anatomy of the genus *Nucula*, from which, however, it differs by the disposition of the gills and the brevity of the oral appendages. No other information was obtained, and as far as any bearing on Molluscan problems, it was very disappointing. But if the study of the soft tissues of the animal was barren of results, it was not so with the shell. Anyone who has examined the very beautiful and attractive looking valves of the Sydney species *Trigonia lamarckii*, Gray, or the much larger Tasmanian species *T. margaritacea*, Lam., will have noticed the peculiar silky lustre on the outside surface, not unlike "shagreen," but much finer and not so rough to the touch. Mr. Woodward in his "Manual of Mollusca," draws attention to this, and says "that the epidermal layer of the recent shells consists of nucleated cells, forming a beautiful microscopic object." (2nd Edit., p. 431.) The so-called nucleated cells will be shown hereafter to be sense-organs of an elaborate character, and the shell will be seen, from the investigations disclosed in this paper, to be a most interesting object, fully sustaining and even surpassing the interest connected with its geological relations.

It must also be noted that the peculiarities of the Australian Molluscan Province, whatever they are, are most visible upon the south coast and in Tasmania. There are two elements which mingle with the Australian Marine Molluscan fauna, and which

contribute to modify its separate character. These are the fauna of the Indian Ocean and that of the Pacific. According to Mr. Woodward's map of the Molluscan provinces, the Australian and New Zealand Marine Mollusca are united together ; but with the exception perhaps of one genus named on the map (*Rotella*), all of the genera mentioned are equally common on the east Australian coast. While admitting the difficulty of entering into detail upon a small map, or indeed any map, it must be said that the information generally given on these subjects has been hitherto misleading.

On the north coast the fauna is that of the Indian Archipelago, into which the Australian element enters very slightly. By North Australia I understand the north-east and north-west coast within the tropics. On the coral reefs of the Great Barrier Reef one sees the same, or nearly the same shells that are exposed for sale in the sampans of Singapore or Penang. The relative proportions seem to be the same. In North Borneo and the adjacent islands one sees the same Marine Molluscan fauna. In fact, it would be very difficult for even an accomplished expert to say whether a collection of shells was made on the Barrier Reef, on the coast of Borneo, or in the Straits of Malacca. Indeed, the differences between North Australia and the Philippine Islands in the fauna we are dealing with, are mostly to be seen in the small or minute shells, and one or two species. The large and showy cones, *Trochus*, *Turbos*, *Nautilus*, *Olives*, *Thorny Woodcocks*, *Clams*, *Pearl-oysters*, &c., are the same in both places and all through the intermediate region. A very few species are local, and probably all but the professional conchologist would regard them as no more than varieties. This Indo-Malayan fauna may be said to extend on the eastern coast as far south as Cape Byron, the most easterly point in Australia, which is considerably outside the tropics. The reason for this is the warm current which extends along the coast from the equator. I am judging by the fauna alone when I say that I believe this warm current is deflected from the land gradually outside the tropics ; but it must make a sudden turn to the eastward, for, at Lord Howe's Island, which is almost due east from Sydney, a tropical marine fauna flourishes, with reef-building corals such as are not found anywhere south of Cape Byron, on the East Australian coast.

But even as far as Port Jackson and to the south of it considerably, some few characteristically tropical species are found. Thus *Typhis arcuatus*, Hinds,* *Nassa coronata*, Lamarck, *Mitra pacifica*, Reeve, *Turbo squamosus*, Gray, *Buccinulus coccinatus*, Reeve, *Tellina striatula*, Lamarck, *Chione marica*, L., all distinctly

* This is found as far south as Tasmania.

tropical shells belonging to the Malayan region, have been dredged in Port Jackson.* The well known tiger-cowry (*Cypræa tigris*, L.), *C. arabica*, L., and *C. vitellus*, L., all come within a short distance of Port Jackson, though they are not common. *C. annulus*, L., I have found on the extreme south coast of Tasmania.

On the west coast of Australia, the influence of the tropical seas extends much further to the south, and though as the south-west Cape Leuwin is approached the Australian element begins to manifest itself, the general character is tropical with the Indo-Malayan elements predominating. This need not surprise us, when we find that such a typical tropical shell as *Fusus colosseus*, Lamarck, occurs at Swan River, W. A., and regular reef-building corals form the dangerous reef of Houtman's Islands (S. Lat. 28° 30' about). A collection of shells from the neighbourhood of Swan River contains so large an admixture of forms common to the Indian Ocean, and so few proportionately peculiar to Australia, that the region can hardly be said to belong to other than the very boundaries of the Australian Province.

The characteristic Australian fauna in the Marine Mollusca is best seen between the Australian Bight and the extreme eastern end of Bass' Straits. It is also found in Tasmania; probably more typically there than in any other seas.

The characters of the Australian region may be thus described:—The possession of peculiar genera, such as *Struthiolaria*, *Macrochisma*, *Macgillivraya*, *Amphibola*, *Trigonia*, *Chamostrea*, *Myadora*, and *Myochama*. The above are not found beyond Australia and New Zealand.

The possession of peculiar forms of well-known genera, or else genera which, if found elsewhere, are only sparingly represented or rare; such as *Phasianella*, *Elenchus*, *Bankivia*, *Rotella*,† *Scutus*, *Risella*, peculiar and abundant volutes, *Fasciolaria*, *Crossea*, *Siphonaria*, *Gadinia*, *Anatina*, *Anatinella*, *Pandora*, *Crassatella*, *Cardita*, *Cypricardia* and *Mesodesma*.

To these must be added the Brachiopoda, which are perhaps better represented in Australia than in any other region. They include *Terebratulina*, *Terebratulina*, *Waldheimia*, *Terebratulina* (fossil only?), *Magassella*, *Megerlia*, *Krausinia*, *Lingula* (three sp.), &c.

The survival of the genus *Trigonia* has already been dealt with; but it derives a greater interest from the fact that we find *Trigonia* represented in tertiary strata by different species from those at

* J. Brazier, Proc. Linn. Soc., N.S.W., Vol. iv., p. 428.

† Found also in India, the Philippines, China, and very common in Japan, but in the Southern Hemisphere confined to New Zealand, and therefore not strictly speaking Australian.

present existing. We cannot enumerate in the Australian fauna a living *Pleurotomaria* as in the West Indies ; but it survived in this region until recent times, as we have a fine tertiary fossil belonging to the genus.

Cephalopoda are well represented in the Australian region. The only peculiar genus is *Pinnoctopus*, a very rare form which was discovered by Messrs. Quoy and Gaimard on the coast of New Zealand, and which is described by them in the second volume of the "Voyage of the *Astrolabe*"* (p. 27, pl. 6, fig. 2). I am not aware that any specimen was ever found except that which was captured on the voyage of the "*Astrolabe*" off New Zealand, which was three feet long. The genus is characterized by the broad wing-like expansions along the sides, which extend in front and envelope all the body. *Spirula* is another genus not confined to the Australian region, but more plentiful on the coasts of Australia and New Zealand than elsewhere, where thousands may be gathered on the beach. The animal is also not uncommon, though perfect specimens are rare. It was a scarcity amongst naturalists, the published descriptions having been derived from one specimen brought home from New Zealand by Mr. Earl, and figured by Mrs. Gray in the "Annals of Natural History," and another described by M. de Blainville. "Mr. Crouch procured a fragment, and an injured specimen was obtained during the voyage of H.M.S. '*Samarang*,' and served Prof. Owen for an elaborate memoir on its anatomy." (Adams, op. cit., Vol. i., p. 44.) There are on the Australian coast many other species of Cephalopoda, such as the Paper Nautilus or *Argonauta*, *Sepia*, several species of *Octopus*, *Sepiola*, *Onychoteuthis* and *Ommastrephes sloanii*, the gigantic cuttle-fish, whose arms are long and powerful enough to drag down large fishing boats at sea.

Some of the genera of the Australian province are not only exceptional types; but while they are found in Australia they are not confined to it, and are only met with elsewhere at a considerable distance, such as *Solenella* of the family of Arcadæ, which occurs in Australia and again at Valparaiso, *Panopœa* of the family Myaciæ, which is found in Australia, and similar species in Japan, Norway, the Mediterranean, and the Cape of Good Hope. I have obtained a living species in Tasmania, and Mr. Brazier records one from Port Jackson. *Bankivia*, a singular genus combining the characters of several genera, nacreous and non-nacreous, which is one of the commonest littoral shells in Bass' Straits, and which is found also at the Cape of Good Hope. *Solemya*, another of the Arcadæ, which is said to occur in Australia and in the Mediterranean; *Trophon*, which is common

* See also Adams' "Genera of Recent Mollusca," Vol. i., p. 20, pl. i., fig. 3; D'Aubigny "Mollusques vivantes et fossiles," pl. ii.

to Australia and Fuegia. Mr. Woodward gives other instances, such as *Monoceros*, *Assiminea*, which however must be founded on some mistake. It is almost needless to say that the earlier works on natural history are not to be relied upon for the habitats of their Mollusca, a large number of species having been attributed to Australia which we do not possess, and many Australian species having been attributed by mistake to other countries. This is certainly the case with regard to these two genera.

The number of species common to S. Australia, Tasmania, and other countries, is relatively small. I do not know of many instances of Marine Mollusks common to Europe and Australia; though it is probable, as far as my observations go, that many species which are regarded now by naturalists as distinct, are in reality only modified varieties of species which are common to Australia and other countries, perhaps even Europe. I have always thought that some of the littoral shells, such as limpets, are so modified by climate that their specific identity is lost sight of. I believe that one species of *Acmea* (*A. marmorata*, T.-W.) has been traced by me from the extreme south of Tasmania through the tropics, Indian Archipelago, China, and so on, even to Japan. What I regard as *Littorina mauritiana*, Reeve, is common to the Mediterranean and Australia, though some naturalists dispute this. *Littorina*, or *Tectarius pyramidalis*, Quoy, which is best represented about Port Jackson and the Heads by large specimens, has also small representatives in the Philippines and in the Malay Peninsula.

The following is a list furnished me by Mr. Brazier of species of Marine Mollusca common to Europe and Australia:—

Crepidula unguiformis, Lamarck. Found in Port Jackson, on the entire coast of America, and in the Mediterranean.

Crepidula aculeata, Gmelin. Port Jackson, southern coast of America, S. Africa, India.

Triton costatus, Born, = *olearium*, Angas (non Linn.). Coast of New South Wales, Victoria, Tasmania, Mediterranean.

Philippia lutea, Lamarck. Port Jackson, Coast of New South Wales, Victoria, Tasmania, Mediterranean Sea.

Pileopsis ungaricus, L. Hobson's Bay or the Melbourne Heads (Bracebridge Wilson) on the authority of Prof. Tate.

From the foregoing remarks it will be seen that the Australian Molluscan province, though possessing special peculiarities, does not offer to the anatomist and physiologist any very exceptional features for investigation. Yet there still remains a sufficiently wide field of research to provide ample material for such an essay as that for which the "Royal Society of New South Wales" has offered its prize. Let it be observed, however, that the mere enumeration of anatomical or physiological features would result

in nothing interesting; besides occupying an immense space to no purpose. I shall confine my observations, therefore, to those lines of inquiry to which my own attention has been specially directed, and which have proved most fruitful in interesting discoveries.

For the convenience of reference, I shall make three divisions in the Molluscan Sub-kingdom, namely:—1. Marine Mollusca. 2. Fresh-water Mollusca. 3. Land Mollusca. This division, which is of course not zoological, is more convenient for me, for reasons which will appear as we proceed. I shall deal in this essay with the Marine Mollusca almost exclusively.

The Molluscan character of any portion of the Australian coast differs according to its climate and situation. In no country perhaps in the World, are there more long stretches of low sandy coast, without rocks or indeed anything but sand-dunes. This is especially the case on the coast of N. Australia, where the shore is so low, and the sea so shallow, that except in a few places no vessel of any size can keep within sight of it, and it is not often visible, except by the smoke of bush fires, at a distance of four or five miles. In such regions, very little is to be seen of littoral Mollusca. A few bivalve shells are scattered along the sand-dunes, the species varying according to the locality. On the north coast these are:—*Mactra*, *Tapes*, *Cytherea*, *Asaphis*, &c. On the south coast such regions are especially rich in *Donax*, *Venus aphrodina*, Lam., *V. lamellata* Lam., (which probably extends as far as China), *Mytilus*, &c.

In places where the shore is rocky, there is a complete change in the fauna. Within the tidal-marks, but generally in the highest part of them, we find a *Patella* outside the tropics, and a *Nerita* within tropical regions, though Patellidæ are not wanting also, with *Acmæa*, *Planaxis*, *Littorina*, *Monodonta*, *Chiton*, &c. On the south coast we have *Patella*, *Acmæa*, and *Siphonaria*, with two or three species of *Littorina*, *Trochocochlea*, and *Risella*. These species are generally out of the water. Within the tropics, amongst the mangrove swamps, there are the usual brackish-water species of *Nerita*, *Cerithidea*, *Telescopium*, *Melampus*, *Auricula*, *Pythia*, *Cyclas*, *Littorina scabra*, L., and rarely *Austriella sordida*, a genus of the author's.*

The above named littoral species offered such special facilities for study, that from the very first they attracted my attention particularly. There are, as all those moderately acquainted with the subject are aware, under the guise of shells presenting no

* See Proc. Royal Society of Victoria, Vol. xvii., 1881, pp. 80-83, pl. 1, figs. 10-11, "On Some New Marine Mollusca." The new genus *Austriella* is distinguished as including thick non-nacreous shells, with a smooth, arcuate, hinge margin, without teeth, with a persistent periostraca.

external differences except those scarcely specific in character, not only distinct genera, but even three distinct families. In this there is nothing very surprising, if we remember that the early condition of embryonic shells is cup-shaped. This persists in some by their growing regularly, and thus they have in the adult condition a more or less elevated and conical shape. The difference between these forms and the whorled, spiral, or heliciform shells, is derived from the fact that the embryonic form develops disproportionately in one direction. The mode of this development gives rise to all those modifications of form which are met with in the Mollusca. From this it may be remarked in passing, how useless any system of classification must be which confines itself exclusively to the form and color of the shell. Thus restricted, conchology was for a long time unworthy of the name of a science.

But while we recognize the great anatomical differences which separate animals which resemble one another in the forms of their shells, we must note the fact that similarity of habits or the conditions of life lead to other resemblances of an important kind. This will be seen from the observations I shall have to make on the eyes I have found in the shells inhabiting the littoral regions. These seem to be in number, size, and disposition, very similar in all the littoral shells that congregate about the tidal marks. I have found that these organs of vision are reproduced in the same manner, or to some extent the same manner, when the shell is subject to much erosion from the alternate action of the air, sun, and salt water. I have found this the case particularly in the genera *Patella*, *Acmaea*, and *Siphonaria*, all conically shelled species: as well as the spiral univalves *Trochus*, *Trochocochlea*, *Senectus*, *Littorina*, and *Risella*. These instances will be referred to in detail further on.

Before proceeding with this matter of the shell, it is advisable to deal with some points of classification, which illustrate in the conically shelled species important physiological and anatomical principles. We find amongst the conical-shelled littoral species, three or perhaps four forms of branchiæ or respiratory organs. In *Patella* they are a fringe round the foot, between it and the mantle. It is interrupted only for a short distance where the head protrudes. In *Acmaea* the gill forms a single pectinated plume at the back of the neck. In *Siphonaria* there is a lateral respiratory orifice leading to a chamber which is covered by a portion of the mantle, forming a pulmonary cavity like that which obtains amongst the slugs and snails, or rather like those Mollusks which are destined to breathe both air and water. In the case of *Siphonaria* there is a gill in the pulmonary cavity.

The function of *respiration* is generally speaking a function of the integument, and is said to be a gill or lung when it is specially

localized. This does not always happen in similar portions of the animal, nor can we regard all the organs which appear to be gills as morphologically identical (Gegenbaur). Moreover, instead of a specialised gill, a modification of the organ of respiration may be found in a respiratory canal system, which is developed in the walls of the mantle cavity. In some Gastropods, according to the author just quoted, this network of canals extends beyond the gills into the neighboring parts of the branchial cavity, which are thereby enabled to take part in the respiratory function. In this way the mantle cavity is adapted to taking in air and becomes a lung. An organ of this kind is found in various forms in very different families of Mollusca. It enables the animal to breathe both air and water. The following observations on this subject, as illustrated in an Australian Mollusk, were made by me in Tasmania. The species referred to is *Siphonaria denticulata*, Q. and G. The shell is irregularly oval, with a protuberance on the siphonal side, with 40 to 50 fine ribs of lighter and darker colors. Animal dull brown, with numerous small light spots of varying size; foot yellowish, shading to orange near the head; mantle brown, fringed at the edge with whitish and black spots. When the mantle is contracted the black spots seem to be the points where it is drawn in. Head, a large and many-lobed mass, forming a cup-like expansion round the very small mouth; no eyes visible, and, though they are represented in Messrs. Quoy and Gaimard's figures of *S. diemenensis*, Quoy, I have never been able to detect anything but a single black dot of varying position on one of the lobes of the head. Above the foot on the left side of the animal is a lobe which forms a kind of semi-circular tube, closely pressed to the shell, and here the mantle is not visible. This tube is the siphon, and is lobed so as to be capable of a kind of bipartition which probably divides the orifice into an excretory as well as respiratory duct. This lobe of the foot acts as a kind of operculum, closing the orifice when necessary. If placed in the open air the siphon tube opens at once, and it is always open when the animal is taken from the rocks which it inhabits, and which are never long covered by the tide. On placing weak carbonate of ammonia about an inch from the orifice, the animal emitted bubbles of air and showed signs of distress by movement and by pouring forth water from the mantle. On immersing in water animals long exposed to the air, many bubbles of air rapidly escaped, and the siphon became tranquil and full of water. In this state the animal continued many days. Carmine dropped into the water, gradually spread out, and was drawn almost imperceptibly into long threads or currents towards the siphon, and then much diluted and in fine streaks. From these facts we may conclude that respiration is accomplished by no muscular

movements, but probably by a ciliated portion of the lung cavity. By the word siphon of course is understood merely the pulmonary orifice. Generally speaking the word has quite another signification in reference to the Mollusca; but its use in an irregular sense has been customary amongst naturalists when dealing with this genus.

Accompanying this peculiarity in the organs of respiration, we have a Radula of a type which belongs to the pulmoniferous Mollusca in both the land and fresh-water genera. In *Siphonaria diemenensis* or *denticula* the buccal mass is red and fleshy, in which two long, thin, rather broad, cartilaginous jaws are imbedded. Amid these the broad Radula is spread, working almost perpendicularly, with a very slight movement backwards, as far as I could ascertain in the few opportunities which the shy and sluggish animal gave me of observing. The œsophagus is a bright orange-yellow, and terminates at the distance of about 20 mil. in a sac of the same colour. The Radula soon becomes a tube enclosed in membrane. It does not follow the œsophagus, but curls round and projects as a closed hyaline tube outside the buccal mass into the cœlom. When the animal is wounded it emits a viscid milky fluid of apparently a different character from the blood of Gastropods.

The Radula with careful manipulation may be easily extracted and spread out. It is not difficult to clean it from the attached membranes, and when spread is about 8 mil. long by 3 broad. It is a series of curved lines of teeth diminishing in size from the centre to the margin. The teeth have a broad crescentic edge, which increases in width downwards, and are fixed upon the membrane. The teeth gradually diminish outwardly to a mere faint line of curved tubercles. The appearance of the whole is more like a series of combs with long curved teeth. There appears to be, properly speaking, no plate from which each tooth projects, and the central tooth from which each row diverges in a curved line is rudimentary.

This correspondence between the organs of respiration and the Radula, would seem to justify those naturalists who wish to make the structure of the dentition a leading feature in the classification of Mollusca. There can be no doubt that in this instance, the dentition is an organ of far higher importance than the shell: in fact the dentition goes a very long way in giving a clue to the habits of the animal; but it is not an indication in every respect. Thus, if we should say that the pulmonary sac for breathing air or water has a certain form of Radula accompanying it, we find organs of respiration associated with almost every form. The common periwinkles on our coast, *Risella melanostoma*, Gmelin, and *Trochocochlea tornata*, Quoy and Gaimard, afford us illustrations of this. In both of them respiration is performed

by means of a gill-plume; but if the Radula of the first-named species is examined in its natural position, it will be found to be exactly like that of the common periwinkle of the British coast. It is a long, slender thread, five or six times the length of the whole animal, and strange to say it lies sheathed in membrane, and neatly coiled up like a piece of rope at the back of the head. This peculiarity is shared by all the periwinkles known to me on the Australian coast, though extending to different genera or sub-genera such as *Risella*, *Tectarius*, and *Littorina*. Without stopping to enquire into this peculiarity, for which many reasons might be given, I may say, that the structure of the Radula itself is that of the British periwinkle expressed in the formula $\frac{3.1.3}{\infty}$. There is a figure in Woodward's "Manual of Mollusca" (2nd edit., p. 252), of the European periwinkle, which does not quite correspond with any of our Australian species.

In *Trochocochlea teniata*, Lam., the type of Radula is entirely that of the turbinate Gastropods or nacreous trochoid shells, the RHIPIDOGLOSSA of Troschel: that is to say the central large tooth with five laterals and an indefinite number of lanceolate uncini decreasing from the centre to the edge of the Radula, until they become hair-like hooks set together like the plumes of a feather.

In *Acmæa septiformis*, Q. and G., or *A. marmorata*, Tenison-Woods, there is a gill-plume at the back of the neck as already stated; but the type of the shell is the conical one of *Patella* and that also is the type of the Radula. This is a long, deep brown ribbon, with pairs of long central teeth and no uncini. (See pl. iv., fig. 3. *Patella tramoserica*, pl. iii., fig. 2.)

So that in these three instances we have illustrations of two different organizations, in which the organs seem to be associated according to no definite rule. In the one case the Radula would seem to follow the structure of the branchial apparatus; in the other a certain form of Radula seems to belong to a certain form of shell, while the branchial arrangements are quite different.

BRANCHIAL ORGANS.—The type of the gills or branchiæ, which in some form or another are placed in the cavity between the mantle and the foot, is a series of filaments forming separate lamellæ. I just refer to the fact that the gill is a differentiation of the integuments, and is superficial primitively, becoming placed in a special cavity by being covered by another fold of the integument. Each gill-lamella is developed from a row of processes growing close to one another and remaining separate occasionally, but in most cases growing together and forming a plate. The union, however, is not complete. Fine clefts exist at intervals between the filaments through which the water passes. "These filaments are not simple prolongations, but loops, so that

they enclose a space (intra-branchial space); when the gill-filaments grow together, this space traverses the whole of the gill-plate, and communicates with the exterior by means of the clefts between the filaments. The water which enters by these clefts is collected into a canal at the point where the plate is attached, and is carried by it to the hinder end of the body. There are chitinous rods in each of the gill-filaments, which form a special organ of support." (Gegenbaur.) This quotation will be a sufficient explanation of the observations which follow.

In all the Mollusca that I have examined, I have seen scarcely any exception to this general type of structure; though there is one species in which I have not been able to find it. This is *Cerithium ebeninum*, Brug., to which frequent reference will be made.*

In nearly all the littoral species referred to, if a small portion of the lamellæ is taken, a circulation can be seen for some time after the death of the animal. In *Patella tramoserica*, Martyn, the gill forms a fringe of separate cylindrical filaments round the foot. There is no plate, properly speaking, though each separate filament is a row of rods arranged at right angles or obliquely to the length of the filament. This is a very peculiar structure, and deserves attentive examination. Like all the gill-organs these filaments are richly furnished with cilia. Down each side there is a wide branchial artery, and the chitinous rods pass from one to the other. Between these the blood can be seen circulating, and the cilia in constant movement, causing the fluid to move in two distinct currents along the narrow channels, so that the corpuscles are visible passing in opposite directions or jostling one another as they are hurried to and fro by the action of the cilia. I have seen this action going on vigorously four hours after the death of the animal. The whole surface of the filament, it should be noticed, is studded with minute pores, possibly to permit a more perfect oxygenation of the blood. The pores are apparently smaller than the corpuscles, which are irregular in size and shape, some being many times larger than the pores referred to. The chitinous rods seem to be hollow tubes, darker in the centre from granular cells. The rod continues to the end of the filament, where the rounded ends give to the latter a wrinkled appearance.

A somewhat different structure exists in the case of *Chiton*, where the general plan of the branchiæ is the same; that is, continued round the foot. It is remarkable that there should be such an extensive gill in the case of these genera, while in the genus *Acmæa*, which is a conical shell attaining to nearly the same size, a small gill-plume at the back of the neck comprises the

* Adams in his notice of this animal, in the "Voyage of the Samarang," gives a dissection of *Cerithium*, but avoids all mention of the gills.

whole branchial organs of the animal. For instance, in *Acmæa alticostata*, Angas, the filaments of the gill-plume are extremely long and thin, attached on one side to the branchial artery which is wide, and with a smaller artery running parallel at a short distance, sometimes anastomosing with the main branch which is the shaft of the plume. In the space between the two arteries, the filaments are indistinctly marked and covered apparently with papillæ. Beyond the smaller branchial artery the filaments extend in long curved regular lines to the outer edge, where there is a second artery at which they terminate. Beyond this there is a margin of cellular substance, from which long, narrow, extremely fine filaments extend and seem to be free, attached only to the edge of the plume.

Trochocochlea teniata, Lamarck, is an interesting example which can be obtained easily from almost any portion of the extra-tropical Australian coast. The gill-filaments are grown together, so as to form a broadly lance-shaped plate. They are very long, but with such small cilia that high powers are required for their detection. The circulating currents I have never been able to see; but one peculiarity is deserving of notice. On the outer edge of the plume there are a few scattered, single, cylindrical filaments, which extend from the free edge about a fourth part of its greatest diameter. These have a kind of spasmodic movement, sweeping round from side to side; and when they are watched with a moderately high power, it will be seen that the tube opens and shuts with a sphincter-like contraction, and a constriction a little within the extreme end. I have not been as yet enabled to ascertain exactly whether this movement was connected with the entry or exit of currents of water, but the general impression left on my mind is that the movement was that of suction, and water was taken into the interior of the gill.

In making examinations of the gills, students need not be restricted to such small species as those mentioned, for we have commonly on our coasts large Mollusca, whose branchiæ will hardly require the aid of a common lens for their dissection and examination, and only that of the microscope will be necessary for minute physiological details. *Haliotis nevosa*, Martyn, *Turbo* (*Senectus*) *gruneri*, Phil., *T. (Lunella) undulatus*, Chemn., are all very common on the south coast, and of large size. I was once fortunate enough to secure a very fine specimen of *Sepia* in Botany. The species may have been *Sepia officinalis*, L., at any rate, it was about two feet long, and was a splendid subject for dissection. The branchial cavity when laid open along the mesial line, exposed a beautiful pair of pinnate gill-plumes at each side of the ink-bag. The pinnæ were given off from a stout stem, which was not unlike in form to the shaft of a feather. The

pinnae supported the lamellæ of the usual gill-like pattern. I believe it is not at all uncommon in Botany Bay for similar large specimens to be washed up upon the beach.

Amongst the Lamellibranchiata the gill plates are associated with the organs of locomotion. Thus in *Lima multicostata*, Sow., which is not uncommon on the north-east coast about the Barrier Reef, we find the mantle-margins separate and the inner margin fringed with long tentacular filaments. These are of a deep crimson color, with transverse lines upon them which make them look as if they had spiral lines inside. The animal swims with a gentle opening and closing movement of the valves, making it progress in a series of small jerky movements. The filaments of the fringe are thus always in movement backwards and forwards, and the water is thrown in a series of waves on to the gill-plates, giving a stream of water for respiration such as would be supplied were the animal possessed of a siphon. It is a singularly beautiful Molluscan gill, and a similar species has attracted the notice of naturalists in Britain. Unfortunately a little touch with the hand breaks off the filaments. They form most interesting objects under the microscope, and continue moving for several hours after being detached from the animal.

The gill of our common oyster (*Ostræa mordax*, Gould,) forms an important and valuable subject for microscopists, which is always within our reach. The different filaments are seen to be united, as it is termed, by concrescence. Between each of them there is a double layer of chitinous rods, each layer being separated by a series of cells lined with ciliated epithelium. These are the apertures between the filaments. Besides the chitinous rods there are transverse divisions between the gill-chambers, consisting of horizontal fibres between each of the apertures. The surface of the whole gill is thickly covered with ciliated epithelium, larger on the divisions, and these cilia keep up a continual stream of water. In this species they are of unusually large size.

The gill-plates of some of the families of bivalves are united together. In the Mytilidæ or mussels this union is small in amount, and gives rise to two orifices, anterior and posterior, the larger of which is the anterior one, and this serves as an outlet for the foot, while the posterior outlet allows the excreta and the water which has been used for respiration to pass out. If the common mussel, *Mytilus hirsutus*, Lam., is taken alive and placed in the water, this movement can be watched and the whole process seen distinctly. If also one of the common Arcadæ, such as *Arca trapezia*, Desh., be taken, it will be found that the gills are united posteriorly to a membranous septum. In the common *Trigonia pectinata*, Lam., or *lamarckii*, Gray, the mantle-lobes correspond with the grooves of the shell, so that it appears to be

in plaits which are rounded at the edge ; but the lobes are disunited throughout, nor do they join until they reach the upper surface of the posterior adductor muscle. The gills are united before and behind the foot.

In Section A of Siphonidae there are short siphons. The part of the mantle which surrounds the orifices already spoken of becomes united, and forms a tube which is double or divided at least internally by a partition. In the lower tube the water passes in, being drawn by a movement of the cilia, and passes out again by the upper tube, the current removing at the same time the excreta. In some cases the siphons are short and the pallial line simple, that is without a deep sinus. Of this we have a good example in the common *Chama* (sp. ?) of Port Jackson. In the family Tridacnidae, which is distinguished by having the adductor muscle single and nearly blended with the pedal muscle, the mantle-lobe is extensively united, with however a large anterior opening. There is a small grooved foot near the hinge. The siphonal orifices are surrounded by a thickened pallial border. This genus is well represented in Australia by the large clam *Tridacna gigas*, L., where the size the organs offers special facility for study. It is very common on all the Barrier Reef.

To mention all the various modifications of the siphonal tube which can be studied amongst our Mollusca, would exceed the limits proposed by this essay. It will be sufficient to mention the genera *Cardium*, *Lucina*, *Cyclas*, *Circe*, *Crassatella*, *Cypricardia*, *Cardita*, and *Venus*, all of which have common species on our coasts, and are typically Australian. Nearly all the genera mentioned above have been examined by me, and do not offer anything of special interest. In *Panopaea australis*, Sow., we have probably the double siphons in their highest degree of development, as they are largely protruding from the shell and covered with a thick wrinkled skin. Living specimens are occasionally met with in the Harbour, but they are rare, though the animal cannot be considered uncommon, as single valves are continually found. By digging for them I am convinced many would be obtained, as they are gregarious.

This seems a proper opportunity, as I am dealing with the organs of respiration, to refer to the circulating fluid or the blood of Australian Mollusca. The blood has formed the object of special study by many naturalists. As early as 1846, Dr. T. Wharton Jones read some papers before the Royal Society of London on the blood corpuscle in its different phases of development in the animal series. He found in the blood of the common whelk (*Buccinum undatum*, Lam.), granule cells and nucleated cells essentially similar to those of the blood of *Annulosa*. In *Mytilus edulis*, L., or common mussel, similar cells were found. The blood of

both species had a tendency, he remarked probably for the first time, to shoot out into amœboid processes. Many other observations have been made, but it will be sufficient now to refer to those of Mr. Ray Lankester "On the Distribution of Hæmoglobin in the Animal Kingdom," read before the Royal Society of London,* and the researches of Dr. MacMunn.† Without detailing all the observations, what refers to this subject may be summarized as follows.

The colour of the blood in invertebrate animals does not belong to the corpuscles, but to the *liquor sanguinis*; but there are many exceptions. The color itself is blue after exposure to the air, due to the presence of a pigment named hæmocyanin, in most cases. On analysis the blood is found to contain traces of copper and iron. Extensive examinations have been made as to the nature of this blood and its coloring matter, particularly in the case of fresh-water mussels, snails (*Helix pomatia*, L., *Lymnæa stagnalis*, Drap., and *Paludina vivipara*, Lam.) &c. Most of these animals have blue blood; though in some this quality does not appear until after exposure.

Dr. Lankester has made special researches on the subject of hæmoglobin in Molluscan blood. He found that it occurred in special corpuscles:—1. In the blood of *Solen legumen*, where it is diffused in a vascular or ambient liquid. 2. In the general blood-system of the pulmonate *Planorbis*. 3. In the muscles of the pharynx and jaws of certain Gastropods, observed in *Lymnæa*, *Paludina*, *Littorina*, *Patella*, *Chiton*, and *Aplysia*. Also in the pharyngeal gizzard of *Aplysia*, being entirely absent from the muscular and other tissues and the blood.

Dr. Lankester found in his investigations amongst Mollusca, that there were many cases of red tissue or liquid in the foot and mantle, and in their nerve ganglia, which might be supposed to be due to hæmoglobin, but are not so, as the tissue or liquid did not give the characteristic bands of hæmoglobin when examined by the spectroscope. The result of all his investigations was that hæmoglobin was found distributed irregularly throughout the animal kingdom, being absent entirely only from the lowest groups. It may occur in corpuscles of the blood or in the *liquor sanguinis*, in muscular tissue or in nerve tissue. It may be present in one small group of muscles, and absent from all the rest of the tissues of the body. He thought that a partial explanation of this arbitrary distribution may be found by reference to the chemical activity of hæmoglobin. Wherever increased facilities for oxidation are requisite, hæmoglobin may

* Vol. xxi., No. 469.

† "On the Chromatology of the Blood of some Invertebrates," Quart. Journ. Micros. Science, Vol. xxv., 1885, p. 469.

be the suitable agent employed. The Vertebrata and Annelida possess a blood containing hæmoglobin, being of greater activity than the Mollusca, which do not possess such blood as a rule. The actively burrowing *Solen legumen* alone amongst Lamelli-branchiate Mollusks and only *Planorbis* amongst Gastropods, respiring the air of stagnant marshes, possess blood containing hæmoglobin. In the former the activity, in the latter the deficiency of respirable gases are correlated with the exceptional development of hæmoglobin. But we cannot as yet offer an explanation for the absence of hæmoglobin from the closely-allied species of *Solen*, and from the *Lymnæi* which accompany *Planorbis*.

Hæmoglobin-bearing corpuscles are, according to the same author, of a peculiar character. When hæmoglobin is absent, other things remaining the same (as with the blood of *Solen ensis*, L.), the peculiar corpuscles are absent also. Such things as colorless corpuscles representative of hæmoglobin do however appear to exist in the case of the fish *Leptocephalus*. In connection with the relation of the colorless corpuscles of vertebrate blood to the red corpuscles, and of the corpuscles of the vascular fluids of Invertebrata to one another and to those of Vertebrates, these facts seem to be important; the colorless corpuscles in one case are only comparable to the colorless in another; the red corpuscles are something apart, which may or may not be superadded.

Dr. Lankester mentions in another place a species of *Arca*, in the blood of which he detected hæmoglobin, and which I believe is of a red color. Without being able to say anything as to the occurrence of hæmoglobin, I wish to record here that one species, very common in all muddy places on the extra-tropical Australian coast, and particularly so in Port Jackson (*Arca trapezia*, Desh., = *A. lobata*, Reeve), has red blood, very like in color and appearance to the blood of a vertebrate animal. When examined under the microscope, the red color is seen to be due to corpuscles with a nucleus exactly like human blood, except that the corpuscles appeared to me to be not quite so proportionately numerous as in the human fluid. There was an absence also of any of the amœboid movements, so well known and so often described. The size also appeared to correspond with that of the human corpuscle with a scarcity of colorless discs.

When a living specimen of *Arca trapezia* is opened, the injury to the tissues, as in the case of the oyster, causes the blood to flow freely, and the heart may be seen to be pulsating at the rate of about 15 or less pulsations per minute. On these occasions it appears like a little vesicle fully injected, and can be easily studied in that position. As already stated, if a piece of the gill is now removed and placed under the microscope, innumerable crowds of

red discs may be seen coursing down the channels around the filaments.

The fact of another species of *Arca* in the Southern Hemisphere having red blood is one of considerable interest, and I trust it will soon be ascertained whether it contains hæmoglobin, of which there can be but little reasonable doubt. The habits of the animal are such as to require some highly oxidizing element. Like *Solen ensis* in Britain, it buries itself deeply in the sandy mud and silt when the tide recedes, and comes to the surface when the water is in. The mud in which it lies buried is so finely lavigated that it can generally sink to considerable depths, and the surrounding ooze must penetrate into every crack and crevice and exclude every particle of oxygen. Under these circumstances it would need, it seems to me, all that hæmoglobin could do for it. The habits of the *Solens* are similar, except perhaps that in burying themselves they seem to prefer sand to mud. Often when a lad I have captured numbers of *Solens* by searching for their place of interment, indicated on the surface by a small perforation like a keyhole. Putting a little salt on the hole, and then a little water, generally brought the animal to the surface. It used to be said that it came up because the salt made it think the tide was rising, but probably as much was due to an unexpected shower bath of strong brine.

There are two species of *Solen* in Sydney Harbour, differing but little from each other; but their blood is red like that of *Solen ensis* in Britain. It may be observed that burrowing alone to great depths is not a habit which necessarily indicates red blood amongst Mollusca. *Natica*, many of the species of *Venus*, *Cardium*, *Mactra*, *Donax*, and many others, are all burrowers, and none of them, as far as I know, have blood different from the usual Molluscan character.

I have not had any opportunity as yet for the examination of the blood of any of our species of *Planorbis*. The red color of its blood has been asserted, contradicted, and re-asserted many times. In Prof. Tate's admirable and painstaking little book on the "Land and Freshwater Mollusks of Great Britain," (London, Hardwick, 1866,) he says, "The species that compose this genus are numerous, inhabit slow running streams, ponds and ditches, feeding on the aquatic plants, and are very sluggish in their movements. A peculiarity possessed by all the genus, may be readily observed by irritating the animal of *P. corneus* or *P. marginatus*, when a purplish liquid is emitted, which is not the blood, for the circulating fluid is colorless," p. 210.

I believe that the one Tasmanian species, and one if not more of the Australian species have colored blood, but I have not subjected the fluid of any of them to microscopic examination.

In a great number of Gastropoda which I have examined, including the following species, I have found red fluids in the buccal masses surrounding the jaws:—*Patella tramoserica*, and the other littoral species already mentioned, such as *Acmæa*, *Siphonaria*, *Risella*, *Trochocochlea*, *Senectus*, many species of *Trochus*: in fact, I do not remember having met with any species in which the buccal mass had not a blood-red color. The appearance around the jaws is just that of raw flesh, but a minute examination shows that the red portions are not universally distributed, but confined usually to the terminations of the bands of muscles. If the buccal mass of any of the Gastropods is placed under the microscope, it is seen to consist of a number of long narrow bands, red at the ends. The spindle-shaped cells are often greatly elongated and band-like in form, surrounded by a membrane. There is no differentiation of those singly and doubly refracting particles, giving the appearance of transverse striation. In all the species I have examined the band-like fibres prevail.*

Before leaving the subject of the buccal mass, it will be well to deal with the cartilages which support the Radula, which in the most of the Gastropods is the only representative of the internal skeleton. In the Trochidæ, Patellidæ, Littorinidæ, and many other families, there are two oblong pieces of cartilage, raised at the edges with a central broad groove in which the Radula lies. The shape of these two pieces of cartilage is somewhat pointed at the extremity, like a tongue in fact. In *Senectus gruneri* there are four pieces of cartilage; that is to say there are two small pieces added on to the posterior end of each jaw, and working with a hinge-like movement. In other species, the extra cartilage is reduced to a mere tubercle, but there is much variety.

In the Siphonostomata, where the buccal mass is contained at the mouth of a more or less long contractile siphon, the arrangement is very different. Taking *Triton spengleri*, Lam., a common species at Port Jackson, as a type, we find a simple tube of thin cartilage surrounded by two muscular coats, one lining the inside and the other the outside of the much thicker cartilaginous siphon. The cartilaginous jaws in the buccal mass are hood-shaped and meet together over the Radula, a part of which is exposed in a kind of little orifice, and where it works backwards and forwards on the particles of food which are exposed to its action. The hooded cartilaginous jaws are bound round with a series of band-like muscles; one transverse band passes over and under them about half-way from the orifice or fissure where the hood-like jaws meet.

*Mr. G. Tryon, in his "Introduction to the Study of Mollusca," (Vol. i., p. 90,) says that in *Arca pezata* the blood is red, and is commonly called "the bloody clam." He speaks also of the coloured blood of all the species of *Planorbis*.

- Though the junction of these jaws is pretty close above and below, they seem as it were to strangle the Radula, and make the teeth project out in a kind of point or bunch. One can easily understand when looking at this instrument, how it is that the Siphonostomata are able to bore holes in shells of such an exactly rounded shape. The appearance of the buccal mass is very much in shape like *Teredo navalis*, L., having the same broad, blunt, conical outline. All the Siphonostomata are carnivorous feeders it is said. As a rule the Radula is very short, and is composed of a short series of long hooks with a sharp blade and a broad curve, something like a sickle. The central teeth are broad, simple chisel-like forms. (See Fig. 4.)

Every one who has examined these animals must have noticed the redness of the termination of the tube. If this is inspected carefully, it will be found that there are two distinct muscular bands, crossing each other, both tinged with red blood. From the back of the buccal mass the œsophagus lies loosely in the tube, being fastened underneath by a narrow series of muscular bands which secure it, but give the greatest freedom of movement.

Orepidula aculeata, Gml., is a small shell which is found in Port Jackson, and I believe in most temperate seas of the World, and strangely enough, always as a kind of tenant in the shell-mouth of a *Triton*. It is one of the Siphonostomata, with a shell of inconspicuous color but peculiar slipper shape. The most of the animal is located under the partition which extends half-way across the shell, giving it the appearance of a minute slipper. The animal is beautifully mottled brown and pale yellow over the region of the viscera, and is quite visible through the septum which is transparent. The siphon projects out through this and is conspicuously red. The Radula is of the usual type, such as I have described above; but there is a peculiarity at the base of the sickle-like teeth which I have not observed in other species. At the curve of the shaft there is a row of eight or nine tubercles decreasing in size from the centre.

I may here mention a circumstance connected with the circulation, which I could not more conveniently introduce elsewhere in this essay. I shall have occasion to describe subsequently the mode in which the shell-structure is permeated by perforations and nerve fibres, to an extent which almost destroys our previously received ideas of its compactness and solidity. In some of the sections I have observed small blood-vessels permeating the shell-structure as well. These vessels are of extreme tenuity, not more than $\frac{1}{100}$ of an inch in diameter; but the most singular fact connected with them is, that something like valves are observable at regular intervals all through the length of the transparent tube. I am not aware whether valves

have been noticed in the veins of the Mollusca ; and in these small capillaries, it is the only instance in which I have been able to perceive them. The fact, in any case, has a most special interest as occurring in the shell-structure, where I do not find that any author has suggested the existence of blood circulation. The tubes were ultimately merged in the thickened shell-structure.

MULTIPLICITY OF EYES IN MANTLE AND SHELL.—It is nearly a century since Poli (*"Testacea utrisque Siciliae,"* p. 153,) noticed the occurrence of certain organs like the human eye in the mantle of *Pecten*. This, after a long interval, was a subject taken up by many observers, and extended to other genera, such as *Arca*, *Pectunculus*, and *Cardium*. In 1877 Dr. Karl Semper published the important discovery that he had made, of eyes in the dorsal papillæ of certain species of *Onchidium*, while it began to be realized that Mollusca generally were better provided with visual organs than had ever been imagined; but the shell was not thought to be the place where they would be found to reside. To use the words of Prof. Mosely, "A Molluscan shell is, moreover, almost the last place in which the naturalist would expect to find eyes, and the Chitonidæ have hitherto in text-books always had the absence of eyes assigned to them as one of the characteristics of their group."

It would be unjust not to mention the labors of other observers in the same field, and therefore the following extract from Prof. Mosely (*Quarterly Journ. Microscop. Science*, 1885, p. 38,) becomes necessary:—"Middendorf (*'Beiträge zu einer Malacozologia Rossica.'* *'Mém. de l'Acad. de St. Petersburg Sc. Nat.'* Ser. iv., t. vi., 1849.) named two distinct layers, of which the shells of Chitonidæ consist, the tegmentum and articulamentum; and Dr. W. B. Carpenter examined the shells of Chitons by means of sections, and observed the perforate structure of the tegmentum in Chiton, writing as follows: "In Chiton the external layer, which seems to be of a delicate fibrous nature, but which is of extreme density, is perforated by large canals which pass down obliquely into its substance, without penetrating however as far as the middle layer. (Dr. Carpenter has kindly lent me his original sections of Chiton shells, and from what I now know I am able to recognize parts of pigmental eye-capsules in one labelled *Chiton spiniger*)." (*"Cyclopædia of Anatomy and Physiology, Article Shell,"* p. 565.) The late Dr. Gray wrote in his paper on the "Structure of Chitons":—"The greater number of species have a part of the valve which is not covered by the mantle, but exposed. This exposed part consists of a perfectly distinct external coat, peculiar I believe to the shells of this family. The outer coat of these valves is separated from the lower or normal portion by a small space filled by a cellular

calcareous deposit, which is easily seen in a section of the valves. (J. E. Gray "On the Structure of Chitons," Phil. Trans., 1848.) In 1869, Dr. W. Marshall ("Note sur l'histoire Naturelle des Chitons," "Archives Neerlandaises des Sciences exactes et nat." t. iv., 1869,) made a great advance in our knowledge. He found that the tegmentum of Chitons was perforated by a series of fine vertical canals, which open at the surface in a series of cup-shaped apertures, and that these vertical canals open into a series of horizontal canals running in the space between the apposed surfaces of the tegmentum and articulamentum; and that these canals opened on the under surface of each shell. He further found that the larger vertical canals, before reaching the surface, became enlarged and gave off each a crown of smaller canals also terminating at the surface in cup-shaped apertures, and that the canals and apertures, small and large, are distributed evenly over the outer surface of the shell. He decalcified the shells, and found in the canal system ramifications of soft tissue, which he recognized as offsets of the mantle, and considered homologous with those of Balanidæ and Brachiopods. He erroneously regarded the soft tissue ramifications as tubular and respiratory in function. In 1882 Van Bemmelen, following up his researches, examined the structure of the soft tissues contained in the shell of *Chiton marginatus*, and discovered that the tegmentum is entirely filled with papilliform bodies, which terminate the branches of the network and occupy the surface perforations described by Marshall. He figures and describes the structure of these papillæ and their relations to the tegmentum, and propounds certain theories as to their homologies which will be referred to."

The really important discovery as to the nature of these organs was made by Prof. Mosely himself. In examining a specimen of *Chiton (Schizochiton) incisus*, Sowerby, he was struck with the resemblance of the minute dots already mentioned to eyes, and further examination proved that such was really their nature.

On searching for eyes on the shells of other Chitonidæ, he found them present in the majority of the genera, differing however in each genus more or less in structure and arrangement. Mr. Mosely announced his discovery in the "Annals and Magazine of Natural History" for August, 1884 (Vol. xiv., 5th Series, p. 141). The following is an abbreviated account of these wonderful organs:—

They are circular or oval in outline, varying in measurement from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in diameter, according to the sub-genus or species. They appear under reflected light as convex, circular, raised dots of highly refracting transparent matter, surrounded by a narrow zone of pigment, or the margin of the choroid seen

through shell substance. In the centre is a small dark circular spot with a brilliant speck of light reflected by the lens.

It is better to explain on the threshold of these observations, a difficulty which will occur to most persons not very intimately acquainted with the subject, as to how these eyes on the outside of the shell could communicate their impressions to the nerve centres of the animal. This difficulty will be met most easily in the words of Mr. Mosely, remarking at the same time that the shell, no matter how hard or apparently independent of the animal, is a structure intimately associated with the integument, and is always permeated more or less by nerve-channels between the different plates of shelly matter. Now in the case of the Chitons, this is the more easily understood from their peculiar structure. They were formerly termed multivalve shells; because they are covered with eight moveable plates of shelly matter, sustained in their places by a cartilaginous frame which is a horny extension of the mantle. The imbedded portion of each plate is produced into two processes belonging to the lowest plate of shelly matter. The exposed portion is very much thickened, of a rugose sculpture and colored, forming a kind of raised, triangular, winged area at each side. This is called the tegmentum, and at the junction of these two plates of shell are the openings through which the nerve branches are given off to form the optic nerves as described hereafter. I may mention, that though Mr. Mosely regards this structure as peculiar to the Chitonidæ, something similar to it exists amongst a very large number of Mollusca, both univalves and bivalves, as far as my observation goes; though of course modified according to the peculiar structure of each. It is more apparent in the case of Chitons, but it is hard to understand in many cases how the juncture is effected, yet I think I shall be able to show how the result is attained in those species in which I have found eyes. I now give the result of Prof. Mosely's examination.

"The entire substance of the tegmentum in the Chitonidæ, is traversed by a series of branching canals, which are occupied, in the living condition of the animal, by corresponding ramifications of soft tissues, accompanied by abundance of nerves. The nerves and strands of other soft tissue enter the substance of the tegmentum along the line of junction of its margin with the upper surface of the articulamentum. A narrow area, perforated all over by pores, so as to have a sieve-like appearance, here intervenes between the two components of the shells, and in some shells the actual margin of the tegmentum itself is perforated. In the case of the intermediate shells, in most genera there are a pair of slits (*incisuræ laterales*), one on either side, in the lateral lamina of insertion; these slits lead to two narrow tracts in the deeper

substance of the shell, which follow the line of separation between the *area centralis* and the *areae laterales* of the tegmentum. These narrow tracts are permeated by numerous longitudinal canals, which lodge each a specially large stem of soft tissue and nerves, which ramifies in the substance of the tegmentum. Corresponding with this tract, on the under surface of the shell, are a series of minute openings leading into it, through which further strands of soft tissue, possibly mostly nervous, pass from the surface of the shell-bed into the shell, to give the general network of soft tissue. In the anterior and posterior shells there are usually a considerable number of such marginal slits, each with a corresponding tubular tract and ramifying strands of soft tissues.

The network of soft tissues contained in the canals within the tegmentum ramifies towards the shell-surface and terminates there either in eyes or in peculiar elongate bodies, which, apparently, are organs of touch. These latter are long, somewhat sausage-shaped bodies, which terminate at their free extremity in dice-box shaped plugs of transparent tissue, which show a somewhat complicated structure. The tegmenta of the shells of most Chitonidæ are perforated at the surface by circular apertures or pores of two sizes, arranged in more or less definite patterns with regard to one another, and sometimes with regard to the eyes also. The end plugs of the sense-organs above described, lie in these larger pores. From the sides of the sausage-shaped sense-organs are given off more or less numerous fine strings of soft tissue which, diverging, pass to the smaller pores above described, and there terminate in very small plugs, just like those of the larger similar organs, but less complex in structure."

Having disposed of the difficulties with regard to the Chitonidæ, he explains the manner in which the soft structures of each eye are located. They lie in a somewhat pear-shaped chamber in the substance of the tegmentum or exposed area of the shell. The portion which would correspond with the stalk of the pear is the canal for the optic nerve, directed towards the free margin of the tegmentum, whence the nerve reaches it. One side of the chamber is pierced by a circular aperture which is covered by a calcareous cornea. This cornea is formed of concentric lamellæ, and its substance is continuous at its margins with the shelly tegmentum. The eye-cavity is lined with a dark brown pigment membrane which projects slightly round the margin of the aperture and forms an iris. There is a perfectly transparent hyaline, strongly bi-convex lens composed of soft tissue and of fibrous structure. It dissolves slowly in strong acetic acid. The optic nerve does not perforate the retina, which is composed of a single layer of very short rods with their ends directed towards the light. Some of the fibres of the optic nerve, without proceeding to the retina, pass round

outside, perforating the choroid, and end at the surface of the shell, or round the cornea, apparently forming a sensitive zone round each eye.

Mr. Mosely was not successful in finding these eyes in all the genera of the family. They were entirely absent from the genus *Chiton* and some others. In that genus the perforations and sense-organs were present, but no eyes. In *Chiton (Corephium) aculeatus*, L., the eyes were present in enormous numbers. He reckoned there must be 8,500 eyes. This is an Australian species. In *Chiton (Tonicia) marmoratus*, Gmel., the eyes are sunk in little pit-like depressions on the shell-surface. He searched in vain also for any similar eyes in the shells of *Patella* and other allied genera. He regarded the shells of the Chitonidæ as possessing a feature peculiar of its kind, entirely unrepresented in other Mollusca.

It need hardly be said that so important and interesting a discovery made quite a sensation amongst naturalists, and the wonder was that such numerous organs should so long have awaited discovery. So important was it deemed that at the British Museum at South Kensington, in the portion devoted to marine conchology, the Chitons were brought into prominence for the benefit of visitors. One of the shells is conspicuously labelled for exhibition, and an enlarged model is placed by the side, showing the eyes on the surface of the shell, the prominent rounded tubercles on the tegmentum beside them, and minute protuberances for pores containing nerves of sense.

Before dealing in detail with what instances Australia furnishes of this remarkable character, a few preliminary remarks must be made. One of the shells on which Prof. Mosely made his most important observations was an Australian *Chiton*, that is *Chiton (Corephium) aculeatus*, which is very common in Sydney Harbour. It is probable that the other genera amongst which he searched in vain for shell-eyes were European species, and possibly the shells were not preserved in spirit, in which case the eyes would be difficult to discover. One further observation has to be made.

It has already been remarked that these shells are nacreous. In the case of *Patella tramoserica*, Martyn, which is the species with which we have been dealing previously, it will be remarked when looking at the shell from the inside that there is a narrow margin at the extreme edge, passing all round the nacreous inner line. This is where the outside plate or tegmentum overlaps the internal or nacreous lining. A similar structure is seen on a very great number of shells, whether they are nacreous or not, and I call attention to it here as an illustration of the conspicuous way in which the double-plated structure is universal amongst the

shell-bearing Mollusca. It is not here, however, that the nerves for the organs of sense communicate between the shell and the softer tissues. If we examine the cup-shaped interior of the simple conical shell of *Patella* we shall find a horse-shoe shaped depression in the interior lining. In this there are special perforations for the passage of nerve-fibres and vessels of circulation. In all the univalve Mollusca there are muscular attachments which perform the same office of fixing the shell in its habitation, and where a communication is established between the hard and soft structures. It is obvious that the passage for the nerves, etc., could not be looked for at the periphery or peristome of the shell, where the tegmentum overlaps; because, though the mantle usually stretches down to it and continues adding to its structure, it can be withdrawn far within the shell when occasion requires it. But the overlapping is important as showing in every case the existence of the tegmentum and the inner plate, as much in every family as amongst the Chitonidæ. In *Patella* the overlapping plate forms a conspicuous, though very narrow margin. In some species of *Acmea* it is wide, and of a different colour from the tegmentum; that is to say, sometimes when the latter is variegated the overlapping margin has a uniform band of colour or *vice versa*. In *Trochocochelea* there are three coats: the tegmentum, the nacre, and a white shelly coat forming an inner lip round the mouth, of broad, dark brown bands and narrow green ones. In *Siphonaria denticulata*, Quoy, it is an extremely narrow margin, not at all easy to see, and sometimes itself overlapped by the broken and split edges of the periostraca. Other conical shells need not be particularized.

In *Risella melanostoma*, Gmel., this margin is not very difficult to see as a light-coloured, narrow band round the external lip and so on to the base of the columella. But the line of junction between the different plates requires a hand-lens to make out. In all of our Australian species of *Littorina* it forms a conspicuous addition to the ornamentation of the mouth of the shell. Of all the Trochidæ the same may be said.

This digression has such an important bearing on the subject matter of these eyes, that I must be pardoned inserting it here for the sake of non-scientific readers, and with a view to certain inferences which I shall have to lay stress upon hereafter. But the important point which has to be here insisted upon is that there are in all shells two plates, between which are nerve-fibres, and as I shall show afterwards, in which are nerve centres.

As far as my observations have gone, I have come to the conclusion that the shell-eyes are by no means confined to the Chitonidæ, and that in fact a multiplicity of eyes of this kind is

the rule rather than the exception amongst the Mollusca. It is now many years since I first noticed the peculiar ornamentation with which some of our coast shells are varied ; more particularly in the radiating lines and papillæ or warts, with which the surface is adorned. This is more conspicuous amongst the bivalves, and I was often struck, when examining them with a lens, at observing the peculiar crystalline clearness of some of these asperities upon their summits. In *Anatina tasmanica*, Reeve, to which further reference will be made, this is especially conspicuous. The whole exterior surface of the shell is rough with little dots, not symmetrically placed, nor uniform in size, though small and sometimes aggregated together in little clusters. But what struck me most about these little marks was, that when I examined them with a lens, I found that each had a little transparent crystalline summit which brightly reflected the light. But almost any shell in its natural state, if carefully examined, I had noticed, had something of the same kind upon its surface. Usually this was so small, that a rather powerful hand-lens was required for its detection. Keeping to the example that I have used all through this paper, I may mention the limpets. In a good shell that had not been much eroded, my attention was early called to certain little marks and dots upon the upper surface which must, I felt convinced have had some meaning. As a rule they appear like little stained pits and depressions, but sometimes forming raised clusters of crystalline projections which correspond with the ornaments on the shell. It never occurred to me to suggest that they were eyes, but I felt convinced they had a purpose, and that an important one, in the economy of the shell. I was equally interested with the glassy hemispherical projections on the calcareous opercula of many shells, especially *Nerita* and the trochiform and turbate Gastropods. The latter still remain a partially unsolved problem to me. One circumstance that served me as a clue, was in the case of *Lima multicosata*, Sowerby, a bivalve, the hooded imbrications on which make a beautifully ornamented shell, covered with sharp asperities. Each of the little hooded scales I observed, had one or a cluster of the small crystalline nodules within it, often at the summit, and I could not help remarking years ago, that it looked to me like a bull's-eye lens placed in a reflector, in a most advantageous position to give light to the animal. Furthermore, even the smooth univalve shells were observed to have a very minute ornamentation of this kind in the fine striæ which follow the spiral windings of the whorls ; but I did not pursue the subject further, though convinced that such a uniform ornament must have a meaning. Structures with no higher purpose than mere ornament are unknown in nature, and perhaps the tendencies of the doctrines of evolution incline us

too readily to forego searching for a purpose in insignificant details. Though this may appear to many a very antiquated idea, in practice it encourages one to attempt the solution of many an interesting problem.

I shared the interest and wonder of the public at the discovery made by the great naturalist of the Challenger, and I immediately recurred to the old observations made on Australian shells, particularly *Patella*, *Anatina*, *Lima*, *Trigonia*, and the littoral shells generally. No time was lost in making investigations, though no success was expected with *Patella*, as Mr. Mosely had looked in vain for the small eyes amongst some species of this genus. With some shells, I was not successful, and, as often is the case, these being the first tried led to discouragement and almost an abandonment of the search. But remembering the more conspicuous instances amongst the genera above mentioned, I renewed the investigation, and was rewarded with the discovery of organs, which I have no doubt whatever, are similar to those described by Prof. Mosely. I am fully aware, however, that what might satisfy me in a matter of the kind will require something more to meet all the objections which may be felt by other observers, and therefore beg to record the discovery, if such it be, with some little diffidence, knowing the deficiencies under which I laboured for want of technical apparatus, and also of experience in the higher paths of microscopical examinations. However, I shall give the public the fullest opportunity of verifying or disproving my conclusions by every detail about my methods and the supposed facts observed. It is to be hoped after this there will not be much error involved. In any case, I feel confident that as the examples quoted are of easy access, my conclusions will be speedily confirmed or otherwise.

Briefly, therefore, I may now state that I have found on a large number of shells, eyes of the kind described by Prof. Mosely; that is, associated with sense-organs and supplied with nerve channels of a similar kind. These eyes have been observed in various forms, on so large a proportionate number of shells, that I am inclined to regard their absence as rather the exception, but as in matters of detail there is considerable difference in the mode in which the eyes occur, their number and position, it is necessary to arrange a classified list of these organs.

Eyes and sense-organs in the Mollusca may be divided into four kinds, that is:—1 Minute organs in great numbers on the outer surface or tegmentum of the shell of both bivalves and univalves. 2. Large and solitary eyes in the shell-substance or on the horny tissues, in size and in special peculiarities to be afterwards described, like the tentacular eyes. 3. Eyes on the mantle-lobes of both bivalves and univalves, generally on stalked pedicels, but

sometimes on the surface of the mantle, or immersed to some extent in its tissue. 4. Eyes and sense-organs on the opercula, generally stalked or on raised tubercles. A short description of each of these kinds is necessary before describing particular instances.

SHELL EYES OF THE TEGMENTUM.—If a section be made of any of the following common littoral shells of Australia, certain appearances, to be mentioned presently, will be noticed. The species I now particularly refer to are *Patella tramoserica*, Martyn, *Acmea septiformis*, Q. & G., *Siphonaria diemenensis*, Q. & G., *Cerithium ebeninum*, Brug., *Turbo (Senectus) gruneri*, Philippi, *T. (Lunella) undulatus*, Chem., *Malleus vulgaris*, Lam., (the hammer-headed oyster), *Mercenaria paucilamellata*, Dunker, *Trigonia lamarchii*, Gray, *T. margaritacea*, Lamarck, *Anatina tasmanica*, Reeve, *Ostrea mordax*, Gould, and *Arca trapezia*, Desh. It will be observed that I do not select these species as being exceptional or extraordinary illustrations (except in the genus *Trigonia*). They are in truth taken indiscriminately from the many shells which I have examined, only I happen to have these specimens before me while I am writing the present remarks. A section through any of these shells shows on the outer surface a thin stratum of partly refractive structure. Under the microscope this layer is seen to consist of transparent capsules with a hyaline covering outwardly, and frequently a distinct lens and pupil within. These capsules are supplied with nerves from below, from a large nerve-ganglion in the shell in the case of the bivalves, and from a spirally shaped trunk in the columella, in the case of univalves. All the capsules cannot be regarded as visual organs, or at any rate they are too minute to ascertain this satisfactorily; but they are all supplied with nerves abundantly. For the most part they are so close together as to form a pavement, but occasionally they are scattered. This layer has been of course observed by every naturalist, and has generally been confounded with the fibrous layer of prismatic shell-structure, but that it subserves a far more interesting and important purpose I think I shall be able to show.

If instead of taking a tranverse section, a portion of the shell is ground flat and thin from below, the eyes can be seen and the sense-organs (through the shell) with great distinctness, sometimes with the aid of a lens, but sometimes requiring to be magnified considerably. They occur in the form of minute pellucid, raised, circular, or oval points, transparent, refracting the light brightly and with a minute dark dot in the centre. They are so thickly scattered over the shell-surface as in some cases to leave scarcely a point which is without them. In some others they are sunk in little pits and depressions, or in the valleys between the rugæ of

the surface. Their position is commonly arranged so as to give vision at every angle to the animal. Of course the majority of the eyes upon the shell-surface could only look upwards if they have no power of movement, about which nothing can be asserted as yet. But I find that every little point or elevation is chosen as a location for an eye or a cluster of eyes, and thus there is a close connection between the surface form and these organs of vision. On the ribs of shells it will often be observed that there are raised nodules, points, or bosses at regular intervals, gradually increasing in size in a radiate manner from the summit to the periphery. Such ornaments, which often form the special beauty of a shell, reminding one of the crockets on spires in Architecture, are lit up by these crystalline optical arrangements, making a shell in which they are well preserved look like a city adorned with rows of street-lamps, especially when the surface is wetted or oiled. The eyes are nearly always so minute as to be only visible with the microscope. When the number and variety of them is considered, some will wonder that they have not been noticed before, but they are seldom preserved on the surface of shells in museums and collections. The scrubbing, washing, decalcifying, and polishing to which they have been subjected has long ago swept away these fragile little crystals. My opinion also is that the animal tissues connected with these visual organs are of a very perishable nature, and that their places are only indicated by pits after a little dessication. The calcareous matter contained in the cornea soon ceases to reflect light, and becomes white and opaque. In very old shells the former presence of these eyes is indicated by innumerable pits, as close as small-pox markings on the human face. In this manner it is not impossible that they may be detected in fossil species.

I have found these visual organs as common amongst the bivalves as amongst the univalves. In some genera they are present in extraordinary numbers. This I regard as specially the case with *Trigonia lamarckii*, already referred to. I have, moreover, good reason for the opinion that such eyes are still to be found amongst shells whose upper plates or tegmenta are formed of fine lamellæ, such as the common oyster.

ISOLATED EYES.—Besides these tegmentary eyes, solitary eyes of larger size are found on the edge of the shell, on the operculum and on the periostraca when it is horny. There are peculiarities about these organs which show them to be quite different from the tegmentary visual organs. (1) They are of much larger size; (2) they occur solitary, in pairs, triplets, or even little clusters; (3) they are irregularly spherical or oval, of dark colour, and highly refractive in the centre; (4) they are probably of the vertebrate type, that is to say the nerve penetrates through

the rods and spreads out on the inner surface, and the rods themselves are reversed; (5) there are special peculiarities in the manner in which the nerves supply these organs, an illustration of which can be seen at pl. vi., fig. 8, which is an eye found in the substance of the shell of *Patella tramoserica* while being ground down for a section. It need not appear improbable that such eyes should become entombed and disused, for an instance is met in the case of *Trigonia margaritacea*, where it will be shown that large eyes like those found in the Chitonidæ exist abundantly on the interior lining of the shell. This instance will be referred to subsequently.

MANTLE EYES.—Organs similar to those described in the cases of *Pecten maximus*, Lam., *P. jacobus*, Lam., and *P. opercularis*, Lam., have been observed in a few bivalves, and probably will be found more numerous. It must not be supposed, however, that every warty excrescence on the mantle is necessarily an eye. Any one who has visited a coral reef in the Southern Hemisphere cannot fail to have been attracted by the beautiful appearance of the clams. As the tide recedes the open valves display most beautiful colours, especially in fringes and dots of the brightest blue and green. These are species of *Tridacna* and *Hippopus*. It may not be taken for granted that these dots are eyes, as Brock has shown that they are warts and flask-like cysts, probably containing chlorophyll (see J. Brock, *Über die sogenannten Augen von Tridacna, &c.*)* I do not, however, think that this settles the question as to all the coloured warts which are displayed upon the coral reefs, by species of *Hippopus* as well as *Tridacna*. It should be a special enquiry with naturalists in collecting in these localities as to the true nature of these organs. They are so large and the species are so abundant that they should afford an easy, as well as interesting field of research.

Associated with such mantle-warts are certain patches of pigment cells which are found at regular intervals on the edge of the mantle as already described. Under the microscope this pigment has usually associated with it minute, highly refractive, spherical cells, much larger than the refractive bodies associated with nerve tissue, and in fact hardly mistakable for anything else than lenses. Under the lens there is a cylindrical prolongation forming a capsule not unlike the membrane forming the prismatic structure in the substance of the shell. I shall mention hereafter an instance of this in the case of a young specimen of *Siphonaria diemenensis* where 80 to 90 of such visual or sense organs were observed upon a portion of the mantle in front of the head.

* Zeitschrift für Wissenschaftliche Zoologie. Sechshundvierzigster Band. Leipzig, 1888, p. 280. A translation of this paper appeared in the *Ann. and Mag. Nat. Hist.*, June, 1888, p. 435.

As far as my observations go these eyes are somewhat like the dorsal eyes of *Onchidium*, and not of the vertebrate type; that is to say the nerve is not spread out on the inner surface of the retina and the rods or cones are not reversed. I take this opportunity of saying that I do not consider the negative conclusions of any observer as decisive as to the character of the organs to which I am referring on the mantle. I have known many able and experienced histologists, possibly from an excess of caution, unable to find eyes in the mantle of *Onchidium*, and this certainly not for want of any manipulative skill in preparing the sections.

Amongst the *Annulata* we find something very similar to what I have described above. Eyes are placed in large numbers on certain organs in their young stage and subsequently change their position. Among the *Chaetopoda*, the eyes which are present in the larva, and even in later stages, disappear or are represented by mere pigment-spots.

OPERCULUM EYES.—The character of these eyes depends upon whether the opercula are calcareous or chitinous. In the former case small glassy tubercles, pedicels or bosses stud the surface of the operculum. The manner in which these occur is so varied that separate details will be required for each species. As a type I may take the genus *Nerita*, the shell of which and the columella are studded with small, oblong, transparent bosses or rounded tubercles. Under the microscope these are found to be penetrated by smaller sense-organs, but there are solitary eyes as well either on raised calcareous pedestals or spherical, sessile eyes. These are also found on the chitinous opercula associated with minute spherical highly refractive bodies, which are like eyes, but hitherto have not satisfactorily shown the minute interior structure which has been detected in other visual organs.

However extraordinary these sense-organs, with a double office may seem, we are familiar with such a state of things amongst the *Annulata*. The abundance of eyes with which the *Platyhelminthes* are furnished, agree in so remarkable a manner with the structure of the organs of feeling, that a condition appears to exist in which specific sensory organs are evolved from mere organs of sensation found in the integument. (See Gegenbaur, Comp. Anat. Vermes Sect. 125.)*

* "Non-zoological readers, when dealing with the genera of the lower sub-kingdoms, must put aside the ideas formed by visual organs of the ordinary type, as the animals have eyes both in number and variety of structure widely departing from the usual acceptation of the term. The following quotation from Gegenbaur in treating of the visual organs of *Vermes* will show what extraordinary variations we may expect to meet with. Speaking of the way in which the nerves are pressed together

With regard to the land and freshwater shells, observations have still to be made, though I incline to the opinion that these will be found to furnish instances such as I have described. In the case of shells covered with periostraca, the land shells especially, and such species as *Triton spengleri*, I have not been able to find these visual organs, and this is also the case with some species of *Chiton*. I do not find that the Chitonidæ are more bountifully provided with eyes than other genera, in fact they are less so, and as for *Onchidium*, the genus in which these wonderful sense-organs were first discovered, the eyes in all the species are proportionately very few. We cannot moreover be sure from the absence of eyes in one particular case, that such a peculiarity is specific, because in some species of *Onchidium* I have found no eyes in one individual of a species and the full complement in another. The greatest number of eyes in any one valve of a shell is in the case of *Trigonia lamarkii*, as far as my observations go, and in this case I think there must be about 12,000 in each valve of an adult specimen.

Those shells which have a smooth or enamelled tegmentum are those in which the eyes are the least numerous, and I would venture to suggest that this may be made up by some special arrangement in the soft tissues of the animal. Thus in *Cypræa* and the cowries generally, all who have seen the living animal will remember the number of papillæ of extraordinary shape with which the inner surface of the mantle is studded. These may possibly be sense organs or something to make up for the optical arrangements which are most probably absent from the shell.

Before entering into any detail about the sense-organs in different species, I may sum up briefly by saying that the presence

into a concave layer, he says: "Influential in the development of this arrangement is the multiplication of the perceptive elements, and the formation of refracting media. Just as the eyes are completely wanting in the majority of the Scoleina which live in the dark, so also these organs undergo degeneration in the Tubicola among the Chætopoda. The eyes which are present in the larvæ and even in later stages, disappear, or are represented by mere pigment-spots, when they enter on the fixed mode of life. The development of the visual organs on the branchial tufts of the head is an adaption of another kind, which is seen in certain Sabellidæ (Branchiommæ); in them the eyes are either placed in large numbers on the pinnate branches of the branchial filaments, or at their ends only. In other Annelides there is a similar change of position as compared with the primitive one. In many there are eyes at the posterior end of the body, as well as on the cephalic segment; and finally in the genus *Polyophthalmus* there is a pair of eyes on each metamere, in addition to those on the head. We here find an arrangement which is not only of importance as bearing on the estimation of the metameres, but is also a proof that visual organs may be developed at points which in other forms only carry sensory organs of a lower kind."

of minute eyes in the shells in immense numbers is a characteristic of many Mollusca. Like every other arrangement of this kind in nature, it is subject to much variation. It is abundantly present or nearly absent, it is larger or smaller, prominent or inconspicuous in different groups. There is sometimes a geographical association of certain forms of these organs, dependent upon the conditions of life being the same, such as the climate, temperature, food, and so forth.

The Siphonostomata have not been subjected to such examination as the plant-feeding littoral shells; but the Tritonidæ and Buccinidæ have furnished abundant instances, amongst which I may name *Triton spengleri*, Lam., *Buccinum alveolatum*, Kiener, and *Polytropha margine-alba*, Fisch., of the family of Purpuridæ. In most of the above-mentioned families the lines of growth are represented by fine imbrications of shelly matter, often forming varices on the spiral ribs. At the junction of the shelly imbrications with these ribs, there are generally sense-organs, which follow one another in regular progression to the mouth of the shell.

In giving illustrations of the way in which these sense-organs occur, a few species only can be dealt with, because the discovery is too recent to have allowed time for minute dissection in a great many cases. I must confine myself to these few, and will continue with the simple, conical, littoral shell with which this Essay was commenced, namely, *Patella tramoserica*.

We find, generally, that a very uniform system of colour prevails amongst the limpets. Radiating lines of brown and yellow spots and angular markings occur very commonly. Beautiful lines of rich deep brown, golden yellow and orange are common among a good many species. What purposes they subserve cannot be said; but that they do belong to some very important economy we may be convinced, for there are certain coloured dots on the edges of the mantle which correspond with the dark coloured rays on the shell. It has occurred to me that perhaps these bands of colour in the shell may serve as pigment-coats for some of the eyes in the shell; though it would be difficult to explain in that case why they should be absent from places where the organs are just as numerous. A little further explanation about the anatomy of the species of limpet with which we are dealing will serve to clear up some matters connected with the eyes or other sense-organs.

I find that in this species of *Patella*, the mantle stretches down to the margin of the upper plate already spoken of. I distinguish three folds of tissue: namely—the shell or testaceous fold which lies next to the shell, the tentacle-bearing or median fold and the branchial fold. All these extend between the foot and the shell, excepting for a space round the head, where the branchial fold

ceases. The outer side of the testaceous fold has a narrow margin like a hem, consisting of two parallel lines of dark pigment, with clouds and dots of the same material between them, extending all round the membrane. On its inner side it has short lines and dots of brownish pigment which correspond with remarkable exactness to the lines of colour on the shell. These dots when examined under the microscope, are seen to be full of small and highly refractive cells. The tentacular fold bears a series of small tentacles, forming a fringe all round the mantle. These tentacular filaments extend slightly beyond the edge of the mantle; they are transparent, but more or less coloured with transverse lines of deep olive or blackish pigment. There are from 90 to 100 of such tentacles in an adult shell. They are quite distinct from the branchial fringe which lies further within the cavity, leaving a small space, between the gills and the muscular attachments of the foot. With the exception of the narrow pigmented margin on the edge of the mantle there is no pigment of a dark colour, except on these tentacles; but the origin of some of them is marked for a considerable distance with a yellowish line, and the space between the ophthalmic fold and the testaceous fold has a slight tinge of yellow, deeper or as deep in tint as the gills. The tentacles are solitary; I have not met with double ones; but some of them have, half way from the tip, a little bulb like the eye-bearing bulb on the tentacles of most of the Mollusca. A great many of these tentacles are quite transparent, of a pale greenish-yellow, and showing no trace of structure except with very high magnifying powers. Some of them, perhaps more than half, have spots and rings of very dark olive or black pigment-cells. Those tentacles on which there is something like an eye-bearing bulb do not, as far as I have seen, show any traces of a lens, or anything indeed but a small amount of pigment, generally disposed in rings round the base of the bulb.

But what I have observed is occasionally small bulbs surrounded with pigment, lying between the tentacular fold and the testaceous fold, which had the shape and appearance of eyes, except that what would correspond with the cornea seemed to be opaque. I hardly wish to assert that they are visual organs, though they may have that function and at any rate deserve further examination.

The inner surface of the mantle is slightly wrinkled, but is capable of great extension to the very outward edge of the shell, and of being drawn in, in curtained lobes, within the margin of the foot. Frequently the tentacular fold is withdrawn between the branchial and testaceous folds, so that the rounded bulbs above described become completely covered, or project in a more eye-like fashion.

To return now to the shell of which an enlarged figure is given at pl. 1, fig. 1, magnified about eight or ten diameters. In this plate it should be remarked the full ornamentation of the shell is not given, but only a sketch of the general design and detail of two ribs. It is supposed also that the shell has all its ornamentation in full detail, which I may state is a thing that is seldom or never met in nature. The smaller ribs are always more or less irregular, and sometimes the larger ones are, so to speak, aborted, as if it were undecided whether they were intended to be large or small. The nodules on the smaller ribs are often raised, scale-like imbrications, but this as well as the colouring is inconstant. The plate represents an ideal shell of a species which, like every other in nature, is subject to great variations. The apex is anterior, and from it proceed in a radiate manner about 40 or sometimes as many as 50 conical ribs; sometimes, but not always, large and small alternated. These ribs are interrupted at intervals with somewhat inconspicuous lines of growth. The whole shell is clouded and stained with lines and blotches of colour as already mentioned. These lines are not confined to the ribs or to the depressions between them; though sometimes they very conspicuously form double lines at intervals on the smaller intercalated ribs at each side of most larger ribs. There is generally a line of colour on the testaceous fold of the mantle corresponding with the lines of colour on the shell. I have already referred to the possible connection between pigment-coats and these testaceous markings. There is a very thin chitinous periostraca on all the shells, which serves effectually to conceal the minor details of the shell-surface. If, however, it is moistened with spirit or clove oil, a wonderful sight will be presented to a good and powerful hand-lens. A number of minute points shining with intense brilliancy are scattered irregularly and somewhat numerous over the whole shell-surface. No particular symmetry can be detected as yet, and even it may require some little experience to perceive them at all.

The sight presented is a very marvellous one, and forcibly recalls the brilliant points of light sparkling out of the darkness in the field of a telescope directed to the heavens at night. One realizes the truth of the saying that what the telescope is to the astronomer, the microscope is to the naturalist. Possibly there is not so much awe and mystery connected with these little diamonds so brilliantly reflecting into the tube of the microscope, for we know that with the aid of this instrument we can resolve the whole structure of even the most minute in a manner we are yet far from being able to do with the stars.

In order to see the full extent and beauty of the arrangement of the eyes on the shell, a little manipulation is necessary. It

should be allowed to macerate in a weak solution of acid: two per cent of nitric acid will be sufficient. The time required for the maceration depends upon the condition of the shell. Shells that are not corroded must be selected, and in spite of the numbers of the species on the rocks, uncorroded specimens are not so common as one might expect. For good, clean specimens of adult shells 48 hours maceration I have usually found sufficient. On removal from the pickle the shell can be lightly brushed with a not too hard brush. On examination now the shell will be found to present quite a different aspect. Along each rib will be seen a beautiful series of tubercles for sense-organs, each of the larger eyes occupying the slight ridge made on the rib by the fine concentric lines of growth. There are regular rows also of larger eyes on the depressions between the ribs. Thus the appearance becomes one of much beauty. A series of shining gems radiating in gradually increasing size, studs the surface of the shell, making it quite dazzling. It is very difficult to convey any idea of the effect of the whole without seeming to exaggerate. As far as my experience goes I have seen nothing at all comparable with it, after years spent in the observation of nature.

Let us now consider a little closely the character of these eyes. Though appearing like a row of shining gems increasing slightly in magnitude from the apex of the shell to the margin, they are not always simple eyes. Sometimes the light will be found to proceed from two eyes of small size placed close together, and sometimes a pair of eyes so closely united that they seem almost like a large oblong one. Sometimes they are a cluster of very minute eyes, as many as five or six, or perhaps more, being found associated together. Though as a rule they occur in rows, this is not without exceptions. Smaller eyes are scattered on the sides of the ribs. I believe they are nearly always smaller when occurring irregularly in this manner. I have chosen this species as a typical one, and as affording with the least trouble an illustration of what I must be excused for calling one of the great wonders of nature. But it must not be supposed that the instance is exceptional; there are many other shells that might have been chosen as examples.

The question will naturally occur to most persons as to how these structures are known to be eyes, and it would be almost sufficient to answer that they are, in position, in character, and as far as one can judge, in construction, the same organs which have been so intimately examined and figured by Prof. Mosely. In the "Quarterly Journal of Microscopical Science" for January, 1885, there are furnished by the above named Professor, elaborate drawings of such eyes from sections. From these it is plainly seen that there are all the characteristics of an eye, and an eye in

no way less elaborate than that which is used for the purposes of vision amongst other animals. A vertical section through the tegmentum and the centre of one of the eyes, shows structures in the following order :—1. A calcareous cornea. 2. An iris. 3. A lens. 4. A retina, with rods, to the inner surface of which are attached the optic nerves. The most of these tissues or organs are included within a pigmented capsule, the opening of which exteriorly forms the iris. As far, therefore, as his observations on the Chitonidæ extended, the eyes are most complete and elaborate. No doubt further observations are necessary, and will not be long in forthcoming, but what we have is amply sufficient to prove that nothing is wanting to these organs to entitle them to be regarded as eyes of the most complete kind.

Now, though I am unable to furnish sections of so complete and satisfactory a kind as those given by the Linacre Professor of Anatomy, not having either the technical skill or the technical apparatus for the purpose ; yet still I have been able to satisfy myself that I have been dealing with the same organs in many Australian shells which he has found in the Chitonidæ. I find first of all that these little glassy structures, when examined with higher powers under the microscope, show the curtain of pigment-cells in the centre forming a ring which we call an iris, though probably it may not be the homologue of what is usually understood by that term. Furthermore in *Patella tramoserica*, within the small crystalline capsule, there is a lens and a retina, with a layer of rods or cells containing the ultimate fibrils of nervous tissue. Behind this the strands of the optic nerve spread out, so that the eyes are not of the vertebrate type, but of the form usual amongst Mollusca. At the base of the capsules, directed somewhat obliquely into the substance of the tegmentum, is a nerve-channel, which appears in the form of an extremely delicate tube or sheath. These sheaths are so closely associated together that they give a fibrous appearance to the stratum in which they occur, and their oblique direction is crossed at right angles by other fibres. Or again this stratum of nerve-fibres has them arranged at almost every angle, so that they give a hackled appearance to the stratum. The fibres terminate at a horizontal line of division which separates the crowded nerve-fibres from the nacreous layer. In this is a mass of nervous tissue which I shall distinguish as Neurospongium.* I find it forming large ganglia connected with the eyes and sense-organs in many shells.

* This term has been proposed by Mr. Sydney Hickson in his paper on the "Optic Tract of Insects." (Quarterly Journal of Microscopical Science, Vol. xxv., p. 219.) He says "The opticon itself consists of a very fine granular matrix, traversed throughout by a fine mesh-work of

It must not be supposed that this analysis of the oblique fibrous layer is applicable as a description of every shell. Let it be understood that I am simply describing now what is observed in one particular species, that is *Patella tramoserica*. I should further state also in reference to this species that the membranaceous nerve-channels to which I have referred are silky and opalescent, of bluish-white or golden colour, and to this the tint of the nacre is owing. A similar structure in other shells has always been identified with the prismatic shell-structures, and it may have been in this case, but I claim for it the interpretation which I here describe.

Besides the eyes on the tegmentum, I have been able to obtain occasional sections of visual organs of another kind on the same species. As these were of larger size they gave greater facilities for examination.

At pl. vi., fig. 8, there is an illustration showing an eye which was revealed in making a section through the substance of the shell of *Patella tramoserica*. It had formerly been on the edge of the periostraca, but had been covered up by the growth of the shell. It was a larger eye than any seen on the shell-surface. It will be seen that the structure is of the type common to the eyes of Invertebrata generally, and different from those which have been described by Dr. Semper as occurring in the dorsal mantle of *Onchidium*. The eyes receive the optic nerve at the base of the rods, and it does not pass beyond them. In the Chitonidæ, as described by Prof. Mosely, the optic nerve which supplies the eye gives off from its strands nerve-fibres which pierce through the capsule and come to the surface issuing from the larger or smaller pores. These nerve-fibres are named by the professor, *Macræsthetes* and *Micræsthetes*. Here we have a different arrangement: a small branch of the optic nerve becomes detached before it enters the eye-capsule and makes its way to the outside where it joins on to the pigment-coat near the cornea.

Possibly we have in *Patella micræsthetes* and *macræsthetes* also, and they may emerge to the surface through some of the sheaths described, which probably are not all connected with visual organs. Sometimes it is very difficult to see the passage of the nerve from the membranaceous tube or sheath here

minute fibrillæ, similar to the minute network of primitive fibrillæ described by Gerlach in the mammalian brain and spinal cord. This description of the minute structure of the opticon applies equally to the epi-opticon and principal ganglia of the body. As this tissue is very commonly met with in the animal kingdom, and has not, as far as I am aware, yet received any separate name, I propose to call it a *neurospongium*. In many insects the *neurospongium* of the opticon is traversed by fibrils, and in some cases it contains a few scattered nerve or even ganglion-cells."

J—July 4, 1888.

referred to ; but generally it forms a cloud of pigment which soon merges into the highly refractive nerve-substance which forms the ganglion supplying all these sense-organs.

In one section of *Patella* the nerve-fibres form a dark cloud of pigment at the base of the tubes, but swept to one side like smoke from a chimney. In another section there were alternate dark and light bands something like rain-clouds on the edge of the horizon at sea. As a matter of fact, it would be difficult to describe the appearances presented in each individual case without entering endlessly into detail, and therefore I must content myself with saying generally that nerve-fibres can be seen entering or emerging from the tubes which subtend the eye-capsules and diffusing themselves more or less thickly through the substance of the nacreous layer. Here they may be followed until they unite in a darker cloud of nerve-tissue and form a ganglion of what I term neurospongium.

These ganglia in the shell substance are of such peculiar structure that most probably the differences from neurospongium in the opticon of insects will hereafter be found more numerous than the resemblances. It seems as if the substance of the nacreous shell was perforated by innumerable foramina, which concentrate from all directions in one point. These are filled with strands of nerve tissue of the usual character ; but these strands are often marked with pigment which gradually increases in quantity so that the centre of the ganglion is rendered almost dark by it, though it is relieved by the innumerable round refractive bodies such as are usually seen associated with nerve substance. I shall have occasion to speak of these ganglia in the substance of the shell further on. As to the dark pigment, the observations already referred to from Mr. Patten will serve as an explanation.*

At the base of some of the membranous tubes leading up to the micropores, there are certain dark bodies, very much like the pigment cells of eyes. They are round, and they seem constructed to fill up the ends of the tube, and moreover they have a central nucleus or a pupil-like dot. They seem like eyes ; but the question will naturally arise, what purpose could eyes serve thus deep in the substance of the shell ; for they are fully a millimetre or more beneath its surface, which relatively to their size, is a deep burial. Yet as the tube is open they may be deep-seated eyes, and this I am inclined to think is their function.

It should be stated here that in the case of *Patella* and some other shells, the membranous tubes here referred to, even when they have not these deep-seated eyes, bear so strong a resemblance to the cones of an insect's eye, that it is not difficult to suppose

* "The Eyes of Mollusks and Arthropods," *Mittheilungen aus der Zoologischen Station zu Neapel*, Vol. vi., Berlin, 1886, pl. 23, fig. 19.

that this is their true character. What is meant, will be better seen when I am describing the shell-eyes of *Trigonia*; but it may be just mentioned here, that the tubes are cylindrical when they are on a plane surface, but when they radiate from a tubercle, they become conical at the base. If I do not use the word cone, it is because I do not wish to adopt a terminology which would seem to take for granted the supposition that the structures are identical in function. There are, however, so many points of resemblance between the faceted eyes of insects and the shell-eyes in some species that no one need be surprised at finding them classed under the same terminology. On the tubercles of the large Tasmanian *Trigonia*, the cornea of the eyes or sense-organs, whichever they may be, becomes detached, and then it is seen so closely to resemble the faceted cornea of an insect's eye, such as the common house-fly, that no one could help identifying one with the other. Moreover there is a very considerable resemblance between the arrangement of the large cerebral ganglia of many insects and the ganglion of the shell. Those who have examined these objects will remember that there is a cerebral ganglion and a ganglion in connection, called the peri-opticon. These various ganglia being separated by comparatively clearer spaces where the nervous fibres decussate, it would be quite easy to point out parts and structures in some shells, *Trigonia* in particular, where a closely similar arrangement exists.

But in addition to the deep-seated eyes just referred to, even in the substance of the shell, we find, as already stated, deep-seated eyes cut off, so to speak, from all communication with the outer world. In the nacre we see fine lines, which represent the former lines of growth in the structure. These have been formerly the edge of the shell, which frequently, as it seems to me have borne eyes. By the growth of the shell this has been covered over with nacreous plates, and the eyes entombed. Thus in more than one place, in the substance of the shell, I have come across eyes which are conspicuous from their large size. A figure of one of them is given at pl. vi., fig. 8, in which the nerve-channels formerly connected with it have entirely disappeared. The eye it will be seen has the structure already described of the Invertebrate type, with the arrangement of the rods reversed. The rods themselves are similar to those observed in the last section of the eye of a limpet just described.

If the nerves have an exit from the plate which forms the inner lining, we might expect to find a channel for their exit similar to that for their entry. And this is what we do find as a matter of fact. There is a small plate of fibrous shelly matter, lining the nacre, and this is densely perforated with membranous tubes which continue through all the fibrous tissue, which here is of the thinnest.

possible description, perhaps not more than a third of a millimetre in depth. The surface of the shell itself is crowded with perforations, giving it the cribriform appearance which is familiar to us in the case of the Foraminifera. Small as these perforations are, there seem to be still finer pores between them. The nerve-fibre can often be discerned as it were blocking up the tube. One can easily understand how it is that nacreous shells so easily periah and fall away into powder: they are so perforated and tunnelled that all idea of their solidity is lost, and one wonders how they hold together as they do.

In the case of the mantle-eyes and the dark pigmented matter the evidence is not always so clear. Though a study of the eyes in the mantle of species *Pecten* and *Arca* has shown us beyond doubt that there are optical organs of this kind; yet somewhat similar structures have been found in other species which can only be doubtfully regarded as organs of vision. Thus, for instance, in a European species of oyster, certain pigment balls have been observed beneath the epidermis with tentacles which are nearly pigmentless and ciliated. There is also pigment scattered irregularly over the surface, which in some way subserves the purposes of vision. These cells or similar ones have been found in the European *Patella*. Two kinds of cell have been distinguished; one of which is supposed to be glandular and to secrete the cuticula, while the other is sensitive to light. Similar organs have been found on Mediterranean species of *Pinna* and *Aricula*, which Will described as eyes, and Carrière regarded as glands. The able American anatomist W. Patten, however, found that the organs consisted of an immense number of conical cells expanded at the outer extremity and drawn out to a point at the inner. They were filled with a mass of refracting, closely-packed cells, which gave them the appearance of gland-cells, and were surrounded by narrow ciliated cells, sometimes faintly coloured at their outer ends. Without going into technical detail, which would be difficult to understand without an explanation of terms, the following may be regarded as Mr. Patten's conclusions. The position of these organs on the edge of the mantle and their hemispherical shape resemble closely the faceted eyes of *Arca*; but they have no pigment and the nervation is unknown. But experiments made on *Pinna* and other Mollusks, show that they possess sensitive powers of vision. In the case of *Aricula* the least shadow causes it to close its shell quickly with a force that indicates considerable nervous disturbance.

With reference to these novel and anomalous sense-organs we must not expect that a uniform type will be followed, and this has been so early recognized by observers that a new series of terms has been devised. Instead of distinguishing certain structures by

terms, which implied that they were the homologues of well-known ophthalmic constituents, a perfectly distinct terminology has been resorted to. We have for instance *Ommatidium*, *Retinophora*, *Retinula*, *Retinidium*, *Ommatium*, *Ommerythrine* and *Retineum*. These are the terms suggested by Mr. Patten and others, and as it is necessary to understand them in order to comprehend the literature of the subject and the terms I may be obliged to use, I shall here give their definitions, observing that we are dealing with the highest or ultimate sub-divisions of structure revealed by the microscope.

Ommatidium denotes the structural elements of all eyes, consisting of two to four colourless cells.

Retinophora indicates the aforesaid cells.

Retinula is the circle of pigmented cells surrounding the retinophora.

Retinidium is the specialised part of the *Retia-terminalia* contained in the cuticular secretion of each cell which forms a rod.

Ommatium is a group of ommatidia in which the retinidia are completely isolated, as in the compound eyes of Arthropoda and Mollusks.

Ommerythrine is the red pigment in all eyes; whether confined to the rods alone, or to the retinulæ, or to the underlying tapetum.

Retineum is a collection of ommatidia in which the retinidia of both retinulæ and retinophoræ form a continuous layer; the retinulæ retaining their pigment and primitive arrangement round the retinophora; such as the invaginate eyes of all Mollusks.

It should be added that in many places upon the molluscan hypodermis, especially where exposed to the light, the cuticula is found to be divided into two layers, an outer, structureless one which is the corneal cuticula of the visual organs, and an inner layer; the retinidial cuticula filled with the ultimate ramifications of the hypodermic nerves.

It is probable then, that where the so-called eyes in reality consist of hardly more than pigment-spots, it is useless to expect in these simple organs, structures which would deserve the titles of lens, vitreous body, choroid iris, and so forth. Nevertheless they are organs of sense and may be justly termed visual organs; though the mode of their operation may be concealed from us as yet, or may never be revealed, because they belong to functions which are utterly outside the reach of our experience. To use the words of Mr. Patten (op. cit. p. 570) "If we study the structure of the eyes of *Pecten* we shall find that the parts really have the function that their names and composition indicate. We see a constant purpose in view, a concentration of the rays of light and the formation of inverted images of external objects upon a sensitive nervous layer, the arrangement of whose elements shows a definite relation to the direction of the rays of light."

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NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia," after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

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The Royal Society of New South Wales.

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ANNIVERSARY ADDRESS.

By C. S. WILKINSON, F.G.S., President.

[*Delivered to the Royal Society of N.S.W., May 2, 1888.*]

WE are met together this evening to commemorate the sixty-seventh anniversary of the Royal Society of New South Wales. On such an occasion it is customary to take a retrospect of the Society's proceedings during the year. In doing so our thoughts are at once directed to those who have passed away from us by death since our last Anniversary Day.

Ordinary Members. Hon. WILLIAM BUSBY, M.L.C., elected 1875; Messrs. EDWIN DAINTRY, elected 1873; AUGUST DUCKERSHOFF, M.D., Leipzig, elected 1882; H. S. HAWKINS, M.A., elected 1877; ARTHUR T. HOLROYD, M.D., Edin., F.L.S., F.Z.S., elected 1876; ARTHUR LEVETT JACKSON, elected 1878; GEO. KNOX, M.A. (Cantab.), elected 1874; JAMES MANNING, elected 1873; JAMES MARKEY, L.R.C.S., Irel., L.R.C.P., Edin., elected 1878; CHRISTOPHER ROLLESTON, C.M.G., elected 1856; JAMES BURLEIGH SHARP, J.P., elected 1876; WILLIAM TUCKER, elected 1868; W. G. WESTON, elected 1877.

Honorary Members. Prof. L. G. DEKONINCK, M.D., Liège, elected 1876; Sir JULIUS VON HAAST, K.C.M.G., Ph.D., F.R.S., elected 1880.

Corresponding Member.—F. B. MILLER, F.C.S., elected 1880.

The Hon. WILLIAM BUSBY, M.L.C., born 1812, died 23rd June, aged 75.—The Hon. William Busby came with his father in the year 1824 from England. Mr. John Busby was the first

A—May 2, 1888.

civil engineer to practice his profession in Sydney; he received the appointment of Mineral Surveyor to the Government, and when Sir Thomas Brisbane arrived his skill was utilised to search for water for the supply of Sydney. The result was the construction of Busby's Bore, whereby a tunnel was made from the Lachlan Swamp to Hyde Park. In this work Mr. William Busby acted as Clerk of the Works, during the period of its construction from 1827-1837. In length it is $2\frac{1}{4}$ miles, with a section of 4 feet by 5 feet. The delivery of water averages 3 to 400,000 gallons daily, which was sufficient for the then population of 20,000.

On the completion of this important engineering work, Mr. William Busby engaged in pastoral pursuits in the Northern Districts and met with considerable success. Some little time previous to his death he was in ailing health, but the end was hastened by a severe chill. He died on Thursday, 23rd June, aged 75 years. He was esteemed by a large circle of friends, and as a Member of the Legislative Council, to which he was elected in 1867, he gave close and regular attention to everything that tended to the public good. He joined this Society in 1875.

ARTHUR TODD HOLROYD, born 1st Dec., 1806; died 15th June, 1887; aged 81.—Mr. Arthur Todd Holroyd was born in London, and educated at Ripon Grammar School. At 18 years of age he commenced to study medicine, first at Cambridge and then at Edinburgh, where he took his M.D. degree in 1830. He however preferred the legal profession, and entered at Lincoln's Inn, but wishing to travel before being called to the Bar, in 1835 he visited Rome and Egypt. He penetrated beyond the great desert into the Soudan, and as one of the earliest of English travellers, passed over the same route as General Gordon traversed to Khartoum. He thence journeyed down the Blue Nile to Senaar, crossed the desert to the White Nile, thence to Kordofan and Cairo. From his personal witness of the extent of the slave trade he was able to make representations to the British Government in aid of its suppression. In 1838 he visited Palestine and Syria; unfortunately

no record of his travels exists in print. In 1843 he landed in New Zealand where he remained two years, and then came on to Sydney where he was admitted to the Bar. In 1851 he was elected to represent Bathurst in the Old Legislative Council, and helped to introduce various reforms. He became a member of the First Legislative Assembly, and in 1860 occupied the post of Chairman of Committees. In 1863 he accepted office in the Martin Ministry as Minister for Works. In 1866 he was appointed Master-in-Equity, and in 1879 Acting Supreme Court Judge. He was a Fellow of the Zoological Society (London) since its commencement in 1827, of the Linnean Society (London) since 1829, and of the Royal Geographical Society since 1839. He joined this Society in 1876.

In farming matters he was an enthusiast. One of his earliest ideas was the introduction of flower culture, and in the growth of choice varieties of fruits he laid great stress, having imported the best stocks from Europe. In order to improve the land by draining, he established the manufacture of drain-pipes and eventually fancy tiles, etc., at the well-known Sherwood Drain and Tile Works.

From 1867 to 1877 he held the position of District Grand Master of English Freemasons in this Colony, and his ability as an Administrator was apparent in the success of the Society.

Although past 80 years of age, he was strong and active to within a few weeks of his end, and he passed away on Wednesday, 15th June, from the decay of old age.

CHRISTOPHER ROLLESTON, C.M.G., born 1817 ; died 9th April, 1888 ; aged 71. Mr. Christopher Rolleston was my immediate predecessor in the Presidential Chair. It was this time last year that he delivered an Address reviewing the general scientific advance of the year.

You are, doubtless, well aware of his public life. He was born in Nottinghamshire in 1817, arrived in N. S. Wales in 1838, and

engaged for five years in farming on the Hunter. In January, 1843, he was appointed Commissioner for Crown Lands for Darling Downs. In January, 1855, he became Private Secretary to Sir Wm. Denison. In March, 1856, he was made Registrar-General and inaugurated the present system of registration. In 1858 the Statistical Register was first published, and the Registration of Deeds transferred to his department. In 1862 the Real Property Act was passed, and its introduction devolved upon him. In November, 1864, he was appointed Auditor-General. In 1870 the present Audit Act was passed. In 1874 he was created C.M.G., and retired from the Public Service in 1883.

He took an active interest in the work of the University, and on the Boards of Insurance Companies and the Mercantile Bank his financial talents found scope. He was elected a Member of the Philosophical Society of N.S.W., and contributed several papers to the Society: 1868—"On the Results of Wheat Culture in N.S.W. for the last ten years." 1870—"On Post Office Savings Banks, Friendly Societies, and Government Life Assurance." 1870—"Statistical Review of the Progress of N.S.W., 1862-1871." 1874—"Criminal Statistics of N.S.W. from 1860 to 1873." 1878—"Anniversary Address." 1882—"Notes on the Progress of N.S.W. during the years 1872-1881." 1883—"Anniversary Address." 1887—"Anniversary Address."

He had accepted a position on the Committee of the Australasian Association for the Advancement of Science, but resigned from a desire to lessen his engagements. On 6th April he was seized with a sudden attack of illness which speedily developed into alarming symptoms, so that no hope was entertained of his recovery. His invariable kindness of disposition won the affection of all who had the pleasure of his acquaintance, and his death will long be felt by a large circle of friends.

LAURENT GUILLAUME DE KONINCK, M.D., was for many years Professor of Chemistry in the University of Liège, but is far better known as a Stratigraphical Geologist and Palæontologist. His chief works have reference to the fossils of the Carboniferous

Period of Belgium, but he has also contributed several memoirs on those of the Eastern Hemisphere.

His first important work was "*Description des Animaux Fossiles qui se trouvent dans le Terrain carbonifère de Belgique*" (2 vols. and supt., Liège, 1842-57). This was followed, and to some extent ran concurrently with his "*Monographie du Genre *Productus**" (8vo., Liège, 1846), which is of interest to Australian students as containing the description of the Australian species of that genus. In 1872, Prof. de Koninck published his "*Nouvelle Recherches sur les Animaux Fossiles du Terrain carbonifère de la Belgique*" (4to., Bruxelles, 1872), in which a revised description of the Belgian Carboniferous Coal-fauna was given. To workers in this continent, however, by far the most valuable of all this eminent observer's works is his "*Recherches sur les Fossiles paléozoïques de la Nouvelle Galles du Sud*" (2 vols. 4to., Bruxelles, 1876-77).* This is a description of the gatherings of the late Rev. W. B. Clarke, extending over a long series of years; and it is deeply to be regretted that the result of so much profound study was wholly consumed in the unfortunate Garden Palace fire in 1882. This is the more deeply to be deplored when we remember that the fossils in question formed the types of many new species, hitherto unknown to Science, and of which many specimens have not since been obtained. Of all his publications, however, that which will carry his name down to posterity as his "*magnum opus*" is that truly magnificent work, "*Faune du Calcaire Carbonifère de la Belgique*," published in folio in the '*Annales du Musée Royal d'Histoire Naturelle de Belgique*' (folio, Bruxelles). He died, July 16th, 1887.

Sir JOHN FRANCIS JULIUS VON HAAST, K.C.M.G., Ph.D., F.R.S., &c., was Professor of Geology in Canterbury College, Christchurch, New Zealand, and Director of the Museum.

*An English translation of this work, with plates, edited by Mr. Robt. Etheridge, junr., Palæontologist, is in course of publication by the Department of Mines, Sydney.

During the first portion of his residence in New Zealand he was occupied in geological surveys in the Province of Canterbury, and on which he published several voluminous Reports, the most important being "Geology of the Provinces of Canterbury and Westland" (8vo., Christchurch, 1879).

Dr. Haast's early geological observations were, in a great measure, made on the glacial phenomena of the Southern Island of New Zealand. During later years, when not occupied with the improvement of his Museum, he devoted himself to the investigation of the Extinct Wingless Birds, and on which he wrote several important papers. Amongst these we may mention "Researches and Excavations carried on in and near the Moa-bone Point Cave, Sumner Road, 1872," which gave rise to much discussion at the time of its publication. Several papers were also written by Dr. Haast on the living Avifauna, Fish, and Cetacea of New Zealand; and we are indebted to him for a contribution to the study of its Extinct Reptilia.

At the Indian and Colonial Exhibition, held in London in 1886, Dr. Haast acted as New Zealand Commissioner, and gave ample testimony of his abilities as an organizer and administrator. For these services he received the honour of Knighthood. He died, August 15th, 1887.

FRANCIS BOWYER MILLER, died 17th September, 1887, aged 58. Mr. Miller was educated at King's College, London, and after having accompanied an expedition to the West Coast of Africa, came out to this Colony in 1854, having received the appointment of Assayer to the Sydney Branch of the Royal Mint on its formation. He remained in the service of the Sydney Mint until 1870, when he was transferred to Melbourne on the formation of the Branch in Victoria, receiving at the same time promotion both in position and salary. On the retirement of Major-General Ward in 1878, Mr. Miller was again promoted, and was twice appointed Acting Deputy Master in charge of the Melbourne Mint. He is well known to the scientific world as the inventor of the chlorine process of refining gold, which has ever since been

in constant use in the Sydney and Melbourne Mints. This invention caused a complete revolution in the treatment of the precious metals, and has been of great advantage to the Colonial Mints, and of considerable profit to the mining interests; but, like many other originators of most useful inventions, he reaped but a comparatively small reward for his important and valuable discovery. Mr. Miller was a Fellow of the Chemical Society of London, and a Corresponding Member of the Royal Society of N.S.W.

At the end of last year, there were 488 Members on the roll. Of these, thirteen have been removed by death; seven have resigned; and ten have ceased to be Members through non-compliance with the Rules of the Society. Twenty-four new Members have been elected during the year; so that the total number of Members on the roll on 30th April, 1888, is 482.

Michael Foster, M.D., F.R.S., Professor of Physiology, University of Cambridge, was elected an Honorary Member on 4th May, 1887.

During the past year the Library of the Society has been enriched by the donation of 1244 Volumes and Pamphlets, two Portfolios of Charts, and 30 loose Charts.

During the past year the Society presented its Journal and Proceedings. Vol. XX. for 1886, to 342 Societies and Institutions, and Vol. XXI. for 1887, to 338, of which a list has been published.

The following new Societies have entered into an exchange of publications since last year, viz: Society of Natural History, Brookville, U.S.A.; Editor of the Journal of Comparative Medicine and Surgery, New York; Wagner Free Institute of Science, Philadelphia; Deutsche Seewarte, Hamburg; German Meteorological Society, Hamburg; Vereins für Erdkunde, Leipzig; Sociedad Científica "Antonio Alzate," Mexico; Sociedad Científica Alemana Santiago de Chile; Société des Naturalistes, Kieff, Russia.

The Society has subscribed to 19 Scientific Journals and Periodicals, and has purchased 90 volumes at a cost of £67 5s. 3d., including Vols. I. to XXXVII. of the Paleontographical Society's publications.

During the past session the Society held eight Monthly and one Special Meeting, at which the following papers were read:— 1887, May 4—Presidential Address, by Christopher Rolleston, C.M.G. June 1—"Recent work on Flying Machines," by Lawrence Hargrave; "Some N. S. Wales Tan Substances, Part I." by J. H. Maiden, F.R.G.S. July 6—"Notes on the experience of other countries in the administration of their Water Supply," by H. G. McKinney, M.E., M.I.C.E. August 3—"Notes on some inclusions observed in a specimen of the Queensland Opal," by D. A. Porter; "Some N. S. Wales Tan-substances," by J. H. Maiden, F.R.G.S.; "The Influence of Bush Fires in the Distribution of Species," by Rev. Robert Collie, F.L.S. September 7—"Origin and mode of occurrence of Gold-bearing Veins, and of the Associated Minerals," by Jonathan Seaver, C.E., F.G.S.; "Results of observations of Comets VI. and VII., 1886, at Windsor, N.S.W." by John Tebbutt, F.R.A.S. October 5—"Port Jackson Silt Beds," by Fred. B. Gipps, C.E.; "Some N. S. W. Tan-substances, Part III." by J. H. Maiden, F.R.G.S. November 2—"On the presence of Fusel Oil in Beer," by William M. Hamlet, F.C.S. December 7—"Some N. S. W. Tan-substances, Part IV." by J. H. Maiden, F.R.G.S.; "Autographic Instruments used in the development of Flying Machines," by Lawrence Hargrave.

The Medical Section held seven meetings, fourteen papers read; Microscopical Section, eight meetings; Sanitary Section, four meetings, five papers read.

The Sanitary Section, after a lapse of seven years, was revived in 1886. Since then ten meetings have been held, when excellent papers on sanitary subjects have been read by:—Trevor Jones; Reuter E. Roth, M.R.C.S.E.; Dr. Quaife; Dr. Ashburton Thompson; G. W. Redfern; T. B. Henson, C.E.

At the Council Meeting, held on the 14th December, 1887, it was unanimously resolved to award the Clarke Medal for the year to the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.

A more appropriate award of this Medal could not have been made. During the last thirty-one years the Rev. Tenison Woods has been well known as a writer upon the Natural History of Australasia. Of his 157 works published since the year 1857 no less than 74 are upon his favourite branch of Science—Geology. I well remember with what interest and profit I first read in 1864 his valuable work, *Geological Observations in South Australia*, and I know that my experience is that of many, for wherever I have travelled I have found his name a household word, so wide an influence have his writings exercised among all classes. His name may be justly associated with that of the venerated geologist, whose life work in Australia this Medal commemorates. We all deplore the illness which prevents him from being present here this evening.

In response to the offer of prizes and its Medal by the Society for communications containing the results of original research or observation upon given subjects, the following were received :—

On the Silver Ore Deposits of N.S.W.	1 paper
Origin and Mode of Occurrence of Gold-bearing Veins and of the Associated Minerals	7 papers
Influence of the Australian Climate in producing Modifications of Diseases	1 paper
On the Infusoria peculiar to Australia	<i>Nil</i> .

The Council at its Meeting on the 27th July, 1887, awarded the prize of £25 and the Society's Medal, which had been offered for the best communication on the "Origin and Mode of Occurrence of Gold-bearing Veins and of the Associated Minerals" to Mr. Jonathan C. B. P. Seaver, C.E., F.G.S., M.P.

The Council has since issued the following list of subjects, with the offer of the Society's Bronze Medal and a prize of £25, for each of the best researches if of sufficient merit :—

SERIES VII. To be sent in not later than 1st May, 1888.

No. 24.—Anatomy and Life History of the Echidna and Platypus.

25.—Anatomy and Life History of Mollusca peculiar to Australia.

26.—The chemical composition of the products from the so-called Kerosene Shale of New South Wales.

SERIES VIII.—To be sent in not later than 1st May, 1889.

No. 27.—On the Chemistry of the Australian Gums and Resins.

28.—On the Aborigines of Australia.

29.—On the Iron Ore deposits of New South Wales.

30.—List of the Marine Fauna of Port Jackson, with descriptive notes as to habits, distribution, &c.

SERIES IX.—To be sent in not later than 1st May, 1890.

No. 31.—Influence of the Australian climate, general and local, in the development and modification of disease.

32.—On the Silver Ore deposits of New South Wales.

33.—On the Occurrence of Precious Stones in New South Wales, with a description of the deposits in which they are found.

I am happy to have to congratulate the members upon the favourable financial statement of the Hon. Treasurer, Mr. R. Hunt, F.G.S., which has been submitted to you by the Council.

From this it will be seen that, after transferring £19? to the Building and Investment Fund, a balance of £59 18s. 6d stands to the General Account for the next year. The Building and Investment Fund now amounts to £384 11s. 1d., which is invested in fixed deposit.

Until last year the Society's Journal had been printed at the Government Printing Office ; but the Government having notified that this practice would be discontinued, it devolved upon the Society to undertake the work at its own expense. The thanks

of the Society were tendered to the Government for the great privilege it has hitherto enjoyed.

We are glad, on this our first General Meeting since his return, to welcome back Professor Liversidge in good health. We feel sure, knowing his deep interest in the Society's welfare, that his tour through Japan, America, England, and Europe, affording opportunity for meeting his *confrères* in Science, and visiting some of the principal Scientific Institutions in the old world, will not only have been of interest to himself, but of advantage to this Society. But for the unremitting attention and energy of Mr. F. B. Kyngdon and Mr. S. H. Cox,—the other Hon. Secretaries, to whom our thanks are specially due,—I fear that in the Professor's long absence we should have experienced somewhat the position of a ship's crew without its captain.

Another active Member of the Society, Mr. H. C. Russell, Government Astronomer, also visited Europe during the year to take part in the Congress of Astronomers lately held in Paris. We may be congratulated on again having his valued counsel and services as a Vice-President for the ensuing year.

Professor LIVERSIDGE in his Presidential address drew particular attention to the necessity for Scientific Education and to the means afforded for such education in this colony, chiefly in the Sydney University and in the Technical College. Many amongst us will, I am sure, also endorse the Professor's remarks in regard to the importance of introducing scientific teaching into our Public Schools. No doubt many a boy with latent abilities for science would rise to be a power for good to his country, were his early educational environment such as to favour the development of his faculties for scientific observation. We cannot deny that in most children the faculty for investigating objects of nature is very great; and if this faculty were directed first upon simple lines, what important avenues of usefulness might not its development lead some individuals into! Thus, to take one useful branch of science, can the elementary knowledge of sanitary laws be too early impressed upon all children whatever may be their future

avocations? For may not any individual possessed even of such elementary knowledge be the means of preventing in one or more instances the growth of germs of some disease which perhaps, originating in the stagnant water of a small house-drain, would spread through a town with such direful effect as we sometimes see to be the case, especially in reference to typhoid. Enlarged diagrams illustrative of the forms and rapid mode of growth of some of the dreaded organisms, explained with the aid of a microscope in a simple manner appropriate to the reason of a child, would afford lessons never to be forgotten, and perhaps, in many cases, would awaken more interest or wonder than that created by fairy tales (which I acknowledge has in itself a special value) and with the manifest advantage that the child afterwards realizes that his imagination has not been deceived, and that his reasoning powers have been strengthened for exercise in fields of usefulness for himself and for his fellows. We know that children often communicate to their parents at home what they learn at school, and if such elementary sanitary knowledge were more taught and disseminated, especially to the children of the uneducated classes, our Public schools would less frequently than now be closed, because they become the means, owing chiefly to the ignorance of the parents, of spreading infectious diseases amongst the children. In some less useful though, perhaps, more interesting branches of science might elementary teaching be also given. It is not, however, my present purpose to refer further to science-teaching, but to the main scope of the work of this Society—science-harvesting, the ingathering of fruit cultivated in the fields of knowledge.

The object of the Society, as stated in the Rules, is one of very wide range, viz.: "To receive original papers on Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History Productions." This plan of work has been well conceived, for commerce which is, so to speak, the physical strength of a nation, depends upon the development of the

country's natural resources, and this development must proceed proportionately as Science, Art, Literature and Philosophy are promoted. And as we see in Australia's unlimited natural stores of wealth a practically boundless field for internal and international commercial enterprise ; so we perceive the necessity, nay our duty, at the present time when the foundation of our national greatness is being laid, to determine that the gradual erection of the superstructure be carried out with the precision and solidarity that Science can demonstrate ; with the symmetry and adornment which the refining guidance of Art affords ; and with that recognition of world-wide relationship which Literature inspires ; while Philosophy, all-embracing, in giving purpose and aim to all, engenders that spirit of self-denying co-operation, which not only advances the knowledge of Truth, but also rewards each worker with the assurance of participating in the culminating unity which Truth reveals.

How, for instance, would the necessities of our iron manufacturing branches of commerce be met, if the latest scientific methods of reducing the raw ironstone to metal were disregarded for the employment of the primitive blast forges ? Is not refinement in the character of an individual or a community to be found expressed, and being expressed intensified, in exhibitions of painting, music, floriculture, and architecture — in the adornment, if only for mutual admiration and sympathy, of the varied palatial buildings which the modern exigencies of home life, trade and commerce require ? How could we have inherited that knowledge which is dispelling the darkness of ignorance and in its freedom-giving light revealing the relationship of every branch of mankind, were it not for the cultivation of Literature ? And whence would the self-sacrificing seekers after Truth derive encouragement and hope, did not Philosophy indicate the interdependence, fellowship and unity of all.

Here then is the great work for our Society—a work based upon true principles of progressive civilization, and advancing the welfare of this country, not only for the country itself, but because

of its connection with all other countries, and of its growing influence for good amongst them. Fulfilling such a position the Royal Society will, no doubt, continue to receive that private and State recognition and support which it now enjoys. But its real vitality and influence do not so much depend upon such aid, as upon the personal work of its Members, however simple or abstruse that work may be. One Member may have some important discovery to reveal; another may have but a single specimen to exhibit to illustrate, perhaps, only the mode of its occurrence: both may be equally worthy of record in the interests of Science. What a rich and vast field for scientific research have we not in this portion of the globe, on the land and in the fertile Australasian Ocean. Its tropical jungles and its alpine heights; the wide-spread open grassy plains and the splendid forest-clad mountains; its beautiful sheltered harbour inlets from the great water-way of the globe, and its interior rivers awaiting engineering enterprise to convert them into navigable highways; its varied and rich agricultural, pastoral and mineral lands, yet to be occupied by millions of people whose profitable labour therein is assuredly indicated; its low lands and high-lands ranging within both tropical and temperate latitudes, with their concomitant climates suited to incomers from almost any other part of the world; its geographical position and physical features offering for the astronomer and meteorologist a terrestrial position for celestial observation without which the science of astronomy would be incomplete; its peculiar fauna and flora embracing living forms of ancient types long extinct in other regions; its branches of the human race; its rock formations, with their included remains of the past life upon the earth, furnishing their data to render more complete the "geological record;" the shallow estuarine and deep sea resources of the surrounding ocean;—these and other interdependent objects in nature justify the most sanguine anticipations as to the great importance and interest attaching to the science work our Society has undertaken.

Nor do we forget that this Society is not alone in the field, though it is the oldest. The kindred Scientific Societies of this

Colony, as well as of Victoria, South Australia, Queensland, New Zealand, and Tasmania, are equally with us in object and aim. The twelve yearly volumes of the Linnean Society of New South Wales afford a rich store of contributions to the Natural History of Australasia, including work of special value, as it embraces much original research.

The recently formed Economic Association, of which Dr. Maclaurin, Vice-Chancellor of the Sydney University, is President, is one which should exercise much good influence upon the present national growth of this country, its object being the discussion of questions arising out of the Science of Economics.

The Australasian Association for the Advancement of Science may now be considered established, and promise is given of its operations being attended with great success. Thirty learned and Scientific Societies in the different Colonies have joined the Association, and the majority have appointed delegates to represent them on the General Council. It is expected that all the Societies which have not yet joined will do so before the General Meeting. A satisfactory list of papers has already been received, and many other papers have been promised. A Reception Committee has been formed, and the Sectional Committees will shortly be appointed. The First General Meeting will take place at the Sydney University about the end of August, and if possible the succeeding Meetings will take place in turn in the Capitals of the other Colonies.

It would be impossible to institute a comparison as to the relative value of the work undertaken by the Sections of the Society: the work of each is essential, as a part, for the completion of the whole. But it cannot be denied that there is not a more important field for scientific investigation than that in which the members of the Medical and Sanitary Sections are engaged. The Medical Section, of which Dr. P. Sydney Jones is chairman, has been energetically at work. It would be presumption on the part of one like myself, occupied with the investigation of geological phenomena, to attempt to review the labours of those who are

working out the present life conditions of the earth : but I may say that there is no one of us but should feel a personal interest in the results of their labours, which so deeply concern the well-being of mankind. There is evidence patent to us all, even to the unprofessional, of the good progress and achievements of Medical and Sanitary Science.

The Microscopical discoveries that have been made as to the cause of many of the most malignant diseases, have revealed conditions which may be applied for the prevention, and to some extent, the cure of disease. Science and practise, by united effort, are fast reforming the sanitary conditions of our modes of living. This is apparent, for in the adoption of remedial measures the death rate in large communities has been reduced considerably. Take for instance London, which for its immense population, is one of the healthiest cities in the old world. Facts are eloquent pleaders. According to the reference in the Annual Report for 1887 of our Government Statistician Mr. T. A. Coghlan, the average death rate of London has since 1871 been reduced from 24·4 per thousand to about 21·5 per thousand, representing an annual saving of 12,000 lives, and a proportionate increase in the length of life to the living. This improvement is attributed to the carrying out of a complete system of sewerage, joined to an efficient water supply. In the same valuable report we are informed that comparing the second with the first half of the period which has elapsed since 1870, the death rate of the city of Sydney has improved about 4·5 per thousand, representing a saving of 600 lives each year, while the suburban rate has advanced nearly 4 per thousand, representing a loss of 800 lives during each year as estimated on the population of 1887. And this deplorable aspect of the state of public health in some of the suburbs, attributable to the absence of efficient sewerage and water supply, is intensified when we are told that the infantile mortality was 51·27 per cent., or more than half the total deaths, and largely preventable—the result of neglect and of ignorance. Who will come forward and help to stay this modern Herodian slaughter of the innocents? Well may Mr. Coghlan remark that the high rate of deaths from preventable

causes forms a pathetic commentary on the absence of sanitary precautions. Or regarded from another point of view: it is estimated that the value of every infant born in the Colony should be at least £40; while the average wealth per head of the community is about £345. What a loss of wealth then to the nation does not the loss of 800 lives each year in the suburbs of Sydney alone represent! By death and national weakness, this disobedience to the laws of Nature, which are the laws of God, is thus already severely visited upon us; and to what increasing extent shall we not suffer, if improvements in sanitary conditions do not keep pace with the increasing population! And further, when we find as English statistics show, that chiefly owing to the large infantile mortality, the average period of life of the wealthier and leisured classes is nearly double that of the artisan classes; that is, where the average age at death of the former is 44 years, that of the latter is only 24 years, are we not appalled at this state of things, which to some extent must always exist where population is more or less concentrated? But cannot the wide difference between the condition of these classes be greatly lessened? Who is responsible for its present state? Doubtless not only the governing authorities, but also many of the people themselves who neglect to avail themselves of the facilities afforded them by Municipal and other authorities for sanitary improvements. This language may appear too reproachful, but when Science demonstrates the cause of, and remedy for the many perishing in our very midst, it would be unworthy of one speaking from the Presidential Chair of this representative Scientific Society, did he not, in referring to this all-important subject, appeal to the sympathy and co-operation of all for immediate sanitary reform—and especially on the present occasion in this Centennial year, when the colony is priding itself upon its marvellous growth, the significant position it has attained, and the prosperous future it anticipates.

The average death-rate per 1000 of the population of New South Wales is 15.55 which compares very favourably with that

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of Great Britain, viz. 21·5, and this is lower than those of France, Germany, and other leading European countries: yet we have just seen what great improvement is possible, and if this were effected New South Wales might become one of the healthiest countries in the world; or to use the words of our Government Statistician "were it not for the pitiable waste of infant life, the death-rate of this colony would not reach more than half the European average" which is 25·63 per thousand; in fact it should not exceed the normal death-rate for New Zealand, viz., 11·33 per thousand. Evidence to the same effect is given in the "Report of the Mortality Experience of the Australian Mutual Provident Society," which deals of course with lives approved for assurance. This report by the Actuary, Mr. Maurice A. Black, states that "The one broad fact which will be found to stand out boldly throughout the whole of these pages is that the mortality experience of this Society has been more favourable than that of any other Life Assurance Office in any part of the world. This is a pleasing reflection for those colonists who have left, and an encouraging one to others about to leave the old country, presumably only to better their circumstances, to find that in their new home their lease of life will be prolonged—that the average number of years which persons of a specified age taken one with another enjoy is greater in Sunny Australia than in the cold and rainy climate of Great Britain."

I will not detain you further upon this subject, but I have made special reference to it, for it is one of such vital importance for the future well-being of this country, and it is one in which many Members of the Society may take a personal and active interest and become public benefactors. I must, however, here acknowledge the effective influence for sanitary reform of the Government Board of Health under the direction of Dr. MacLaurin, also of the Water and Sewerage Board.

Dr. Oscar Katz is engaged upon important work in his bacteriological researches which are being published by the Linnean Society.

The New South Wales branch of the British Medical Society is also doing good work. The President in his late annual address, amongst other subjects, refers to the alarming spread of rabbits over the western portion of the colony. It is a matter of grave importance and one which may well engage the attention of scientific men. Over a large area of country such as ours, it is manifestly useless to attempt to eradicate or even to stay the progress of the rabbit pest by artificial methods, for the rabbits under favourable circumstances, multiply faster than it is possible to kill them by ordinary means : it is said that the progeny of a pair of rabbits in the course of three years amount to over three millions. I have recently travelled through the Barrier Ranges and have seen them so swarming with rabbits as to lead one to believe that unless some effective remedy be employed, a large portion of the country will have to be abandoned by the pastoralists, which means immense pecuniary loss to the colony at large. The Government recognising the importance of this matter offered a reward of £25,000 for a satisfactory method of destroying the pest. This induced much attention being given to the subject both in Australia and in Europe, with the result that several natural methods have been proposed which have been deemed worthy of trial, viz., the chicken cholera disease by the eminent M. Pasteur, and another disease remedy by Messrs. Butcher and Ellis of Tintinallong. M. Pasteur has deputed three savants who are accustomed to micro-biological researches, Dr. Hinds, Dr. Loir and Dr. Germont, to demonstrate his process in this colony. It will be remembered that M. Pasteur was elected an Honorary Member of this Society at its annual meeting in May, 1883. Referring to this in a letter which I received a few days ago from M. Pasteur, he says :—
“ Dans la délibération que la savante Société a prise à cette occasion, elle a bien voulu désigner mes recherches sur la part que les organisimes microscopiques prennent au développement de diverses maladies. J'étais loin de penser alors qu'un jour viendrait où j'aurais à m'occuper d'un fléau qui désole vos

riches et immenses contrées agricoles et qui j'aurais à proposer à votre Gouvernement, pour détruire ce fléau, précisément une maladie microbienne."

I am informed by Mr. F. B. Kyngdon, Chairman of the Microscopical Section, that during the past year a gentleman resident in Sydney—Mr. Francis—found that by applying to the eye-piece of a microscope the analysing prism of the polariscope, the resolution of a high-power objective was intensified to a marked degree. The method was illustrated at the Monthly Meeting of the Royal Microscopical Society, London, in November last, and the experts present—while fully admitting the valuable results obtained when 'close-lined' tests were shown with oblique light—were unable to account satisfactorily for the optical principles upon which the advantage is based.

This method of intensifying the resolving power of microscope objectives does not endow a glass with powers beyond what it originally possesses, but it enables it to perform exceptionally well. The action of the prism appears to prevent a slight confusion of rays which may tend to mar the best resolution. In practice this unexpected result of the prism may prove of practical benefit in the workshop of the artist who constructs those perfect specimens of human skill, the modern high power microscope objective; and it is quite possible that some advantage may be gained by its use in the laboratory of the student of Bacteria and other minute forms of life whereby a glimpse may be obtained of an otherwise nearly invisible process.

As a valuable assistance to Microscopic observers Photography is becoming more and more indispensable. The recent advance in the dry-plate process places within the reach of everybody a simple, cleanly, and most accurate method of recording results. In the study of Bacteria, micro-photography will be increasingly depended upon. Several very excellent photographs have been taken by members of our Society during the last few months, and I understand that considerable interest will be given to this subject during the coming Session of our Microscopical Section.

In Astronomical Science the year 1887 will be marked as that of the first great Conference of the World's Astronomers—a Conference called together to secure systematic and united effort in carrying out the grandest work that astronomers have ever attempted : that is, to make a complete and accurate chart of the whole heavens down to the stars of the 14th magnitude. Some idea of the dimensions of this undertaking may be gained from the fact that, as I am informed by Mr. Russell, Government Astronomer, when all who can take part in it are ready, which will probably be in the year 1889, it will take from six to eight years to get the 50,000 photographs which this work involves.

Many of these photos will record thousands of stars, and the whole record is estimated to contain 20 millions. And after that comes the labor of measuring, recording and publishing the position of every individual star ; no one yet dares to say when that will be done, but when all the labour has been done, and the few final figures for each star are printed, they alone will give about 2,000 quarto volumes of 300 pages each.

But the fact that this work is to be undertaken, marks a great step onward in the appliances now at the command of the astronomer, resulting from recent advances in photography, optical work and mechanism, but mainly in photography. Sensitive plates are now made of such marvellous quality, that stars and nebulae invisible even with the most powerful telescopes, can be photographed ; and by the aid of new appliances the veteran solar photographer "Janssen" proposes to get photos of the Sun which will reveal every detail of the changes constantly going on in it, and thus lead the way to answer the question which the meteorologist is asking, "What is going on in the Sun to account for these strange conditions of weather ? And there can be no doubt that the great impulse now given to astronomy by the work of the Paris Conference, will do very much towards tracing the solar conditions, which are of such vital importance to the inhabitants of the earth in their effect upon climate.

The meteorologist has slowly traced the phenomena of storms, and in the daily weather charts published here, and generally in Europe, we can trace the track of the storm with its concurrent weather, including rain, for several days in advance. Rain is no longer the unknown phenomena of which no explanation could be given, it is now known to hold a definite relation to the storms known technically as cyclones, and as their track can be predicted, so can the rain : it is but a step onward to unravel the cause of the cyclones of a particular season, why they follow this cause or that ; in the one case they bring abundance of rain, and in the other drought. And when that is done by the aid of astronomers, the meteorologist's prediction will take a wider range and give us the weather for the season. It requires no words from me to point out the importance of such an advance in a country where wealth and weather are so intimately related.

With the exception of a few papers by Mr. Chas. Moore, F.L.S., Baron Sir Ferd. von Mueller, and the Rev. J. E. Tenison-Woods, F.L.S.. this Society has contributed but little to Botanical Science notwithstanding the large amount of work that yet remains to be done. In reference to this subject I will give you some recent observations by the Rev. Dr. W. Woolls, F.L.S., who, next to Baron von Mueller has done so much in making known the botany of this Colony, "The progress of Botanical discovery in Australia has been very marked since the beginning of this century. It was in 1805, that the eminent Botanist Robert Brown, took with him to Europe from these shores some 4,000 species of plants. Many of these were new to science, and illustrative of the vegetation peculiar to Australia. After several years of labour in arranging species and genera systematically, he laid the foundation of our Flora in his celebrated '*Prodomus Floræ Novæ-Hollandiæ et Insulæ Van Diemen* in 1810,' and in so doing showed the superiority of natural to artificial systems. For more than half a century, (during which enterprising travellers and explorers added many species to those previously discovered) much valuable information respecting indigenous plants was scattered through

the works published by Oxley, King, Cunningham, Sturt, Mitchell, Leichhardt, &c. It was not however, until 1878, that Mr. Bentham, assisted by Baron Mueller, described in the seven volumes of the *Flora Australiensis* all the known plants of Australia, and thus collected together in one elaborate work after sixteen years from (1863 to 1878) of unremitting exertion a full account of our Flora as derived from all sources, whether from the accumulated collections in Europe, or from those procured by Baron Mueller in Australia. The *Flora Australiensis*, it should be observed, describes the dicotyledonous and monocotyledonous plants fully, but of the acotyledonous orders only the Lycopodiaceæ, Marsilaceæ and Filices, or what are termed the higher Vascular Cryptogams. Between 1858 and 1881 Baron Mueller published eleven volumes of his *Fragmenta Phytographiæ Australiæ*, containing descriptions in Latin of new and rare plants, and also, in the last volume, lists of the lower Cryptogams furnished from various sources. His *Eucalyptographia*, his work on the Myoporinous plants of Australia, and that, now in course of publication, on the genus *Acacia*, have contributed materially to clear up difficulties in the classification of species, and by means of well executed figures, to place before the student in almost living reality some of the most interesting of Australian plants. In his 'Systematic Census of Australian Plants,' to which he has added several supplements, he has given a comprehensive view of the Flora of Australia, showing the species peculiar to the respective colonies, and raising the total number of vascular plants to nearly 9,000. Whilst the progress of the past, especially during the last quarter of a century, has been most satisfactory, it is evident that the lower Cryptogams afford a wide field for scientific investigation ; and it is to be hoped that specialists in the various departments may be found to accomplish for the Mosses, Lichens, and Fungi, what has been done so ably for the higher orders of vegetation by Brown, Bentham, and Mueller. Professor Harvey in his splendid '*Phycologia Australiæ*,' has done much for the Marine Botany of these coasts, but as he

intimates in the preface, many species of *Algae* have yet to be added to the 800 recorded by him. Baron Mueller, through the labours of Dr. Sonder, as acknowledged in the eleventh volume of the *Fragmenta*, has raised the number to 1056; but as these are given merely in lists without any descriptions, there is still a large amount of work for the phycologist to supplement the labours of Harvey. The great desideratum then at the present day is an additional volume to the *Flora Australiensis*, for the purpose of affording an account of all our known acotyledonous plants, arranged systematically, according to their orders and genera, and furnished with descriptions on a plan similar to that of the other volumes. It is doubtful whether the supplementary volume could be prepared in the Australian Colonies without reference to European Collections, as typical specimens are for the most part limited to the Museums of Europe, and the aid of eminent specialists would be required for the comparison of specimens. "Hooker's Handbook of the New Zealand Flora," affords an admirable example of what may be done for our lower Cryptogams, for although that illustrious author modestly acknowledges, that "many years may elapse before the multitudinous New Zealand genera and species of these very obscure tribes of plants are fully known," he has given excellent descriptions of all the commoner and conspicuous ones, and left it for future specialists to fill up the grand outline which he has so scientifically delineated.

In Physics and Mechanics there is a wide scope for practical science work in this new country. I will but allude to one branch of Physics—Electricity. It is not quite 51 years since Wheatstone and Cooke made their successful practical experiment of telegraphing over a distance of two miles. Now every civilized country is becoming netted, as it were, with wires for Telegraphy. Our own Colony has shared in this spirit of progress, and possesses more than 20,000 miles of telegraph lines. It is only 38 years since the first cable was laid between England and France; at the present day the length of the submarine cables would girdle the earth five times. A message can be sent round the World in

twenty minutes; and by a single wire five messages can be sent in one direction. When we consider this, and the marvellous applications of Electricity in the production of light, sound, heat, and motive power, we stand amazed at the prospect of possible discoveries yet to be made for our individual benefit and for the unification of mankind.

It augurs well for the future of this Colony that the Sydney University has provided for efficient teaching in these subjects and in Engineering. It is to the University, and also to such Institutions as the Technical College that we look to the future for well trained observers, whose scientific researches it will be the object of this Society to record.

Geology and Chemistry as applied to Mining and Agriculture may well engage the attention of this Society. Investigation in this direction will assuredly lead to results of much pecuniary advantage to those whose occupation lies in the development of two of the greatest industries of New South Wales. The knowledge of the modes of occurrence of mineral deposits will often afford a guide not only in the search for minerals, but also in conducting mining operations, especially when faultings in the strata or other difficulties occur. And the successful treatment of the complex ores, which many of the more simple or oxidized ores will pass into as the lodes are followed down, must depend upon careful management under proper chemical and metallurgical direction. Such management will no doubt also lead to the utilization of the by-products and the consequent introduction of new industries. It is satisfactory to see the announcement that, with the view of aiding in the development of mining, the Minister for Mines proposes to establish central testing works where bulk samples of ore can be treated. The little book "*Mines and Minerals*" lately published by two of our members; Messrs. S. H. Cox and F. A. Ratte, affords valuable geological instruction for miners.

A second edition of the "*Mineral Products, Geology, and Coal Mining of New South Wales*," by Harrie Wood, C. S. Wilkinson,

and John MacKenzie, has recently been issued by the Department of Mines ; and a new edition of "*The Minerals of New South Wales*," by Professor Liversidge, M.A., F.R.S., has just been published.

Some idea may be formed of the importance of the mining industry from the statistics given in the Annual Report of Mr. Harrie Wood, Under-Secretary for Mines. It is stated that the value of the mineral production for the year was £3,165,938, and that of the total production of minerals to the end of 1887, £72,938,124.

Then as to Agriculture. A glance at the geological map will show that about one-half of the area of the Colony consists of formations which produce soils suitable for cultivation. And as these formations occur at all altitudes up to 7,000 feet above sea level, and under nearly every condition of climate—from the almost tropical atmosphere of the Clarence and Richmond River Districts to the cold air of the Kiandra Mountains ; and from the humid atmosphere of the coast lands to the dry air of the interior, with a variable rainfall throughout as indicated on the Government Astronomer's map—almost every class of agriculture may be carried on. The importance of this is enhanced from the fact that the principal districts are either within easy access of waterway to the ocean, or within one day's journey by rail from the Metropolis. The value of the Agricultural production for the year 1887-8 is about £3,600,000.

It is, therefore, a matter of great moment that scientific observations should be made in numerous localities as to the average and periodic rainfall ; the character of the soils by analysis, whether deficient or not in the elements necessary for the growth of certain kinds of agricultural produce ; the effects of cross-fertilization upon certain plants ; to ascertain the nature of plant diseases ; and to determine, with a view to forest culture, what species of timber trees and trees producing tanning-bark are most suited for each district.

Mr. J. H. Maiden, Curator of the Technological Museum, Sydney, has contributed to this Society several valuable papers upon the Tan-substances obtained in New South Wales. And Mr. Angus Mackay, under the auspices of the Board of Technical Education, has been doing good work in lecturing in the principal farming districts upon agricultural science. But practical experience founded upon scientific observation is specially needed, and such might well be obtained on the experimental farms which it is said the Government is about to establish in the different districts.

For geological investigation, New South Wales presents a region of unsurpassed interest—an interest of a three-fold character, as viewed in its purely geological, palæontological, and mining or economic aspects.

The surface features of the Colony—comprising plains, mountains, and precipitous ravines—are composed of rock formations, which extend beyond the lines marking the political bounds of N. S. Wales, and connect with others to form a union of great value in aiding the completion of the Geological Record as revealed in the various land surfaces of the globe.

The geology of our Colony, therefore, to be rightly understood, must be studied in connection with that of the other Colonies; and in like manner our Australian Continent, though so isolated, is indispensable as a field for research before a true interpretation of the geology of the earth can be arrived at. Thus Geological Science not only compels a union of workers in the different provinces of Australia, but throughout the world, and in this union each worker is rewarded by a sense of the value of his share in the progress achieved.

New South Wales affords a field of wide extent as yet but little explored. Notwithstanding all that has been done, including the life-long labours of the late Rev. W. B. Clarke, who laid the foundation-stone, so to speak, of Australian Geology, even the foundation itself is at present incomplete.

On another occasion I purpose referring to the history of geological exploration in Australia,—a history recording the work of such illustrious men as Strzelecki, Grange, Stutchbury, Dana, Jukes, Darwin, Gould, Hardman, Murray, Brown, Selwyn, Tate, Tennison-Woods, Daintree, and especially the Rev. W. B. Clarke, whose memory is cherished, not only in this Society, for his beloved character and devotion to Science, but also in the hearts of the toiling miners, and of his many friends throughout this country.

But in addressing you this evening, I wish to draw attention not so much to past labours in the field of Geology, as to some of the work that has yet to be accomplished ; and let me say what a splendid work it is—so attractive in scientific interest, and so conducive to results of practical importance in the development of the natural products of the colony. The paleozoic formations offer the most extensive range for investigation, almost throughout the whole series evidence of ancient organism is abundant. But though numerous collections have been made and described, so little is known that not even the limits of the several formations have yet been assigned ; nor are we in a position at present to indicate with certainty which are the oldest rocks in Australia. In South Australia, Professor Ralph Tate has found limestone below beds containing the Cambrian Fossils discovered by Mr. O. Tepper ; and some metamorphic rocks in Western Victoria are believed by Selwyn to be pre-Cambrian or Laurentian ; but the gneissoid mica and hornblende schists, and limestone of the Barrier Ranges, which have a very ancient appearance, have yet to be determined. Nor can this be arrived at until more extensive paleontological examination, and sections of the strata from actual survey have been made. The same observations will apply in regard to the enormous development, especially in Eastern Australia, of fossils of Lower and Upper Silurian, Devonian, Carboniferous, and Permian Ages have been obtained. The only two horizons actually determined as yet are on the authority of Professor McCoy—the Llandeilo in Victoria,

noticable from its graptolites, and the Upper Silurian, probably Wenlock and Ludlow, also in Victoria, the latter undoubtedly extending into New South Wales.

To add to the perplexity some of the strata contain fossils characteristic of the formation below them mingled with others belonging to the overlying series : these have been named by the Rev. W. B. Clarke "passage beds" for the sake of convenience for classification. Nor have the natural thickness and order of sequence of the strata composing each series been ascertained ; their associated minerals and fossils have been but little determined ; their position and extent require mapping out ; and the suitability of their soils for agricultural and pastoral purposes is not yet fully known. I may here, in passing, say that an accurate survey of the Coal Measures in the Maitland district has just been completed by Mr. T. W. E. David, B.A., F.G.S., Geological Surveyor. This locality was selected by me for a detailed Geological Survey because the Middle and Lower Coal Measures are therein well represented ; for it is only by careful survey of such typical localities that information of value can be acquired for the elucidation of the same Coal Measures elsewhere. It is gratifying to know that Mr. David's work has been very useful, not only in scientific results as regards the order of sequence of the different strata and of their associated fossil remains ; but also from a direct practical point of view, in the discovery of two coal seams which have since been opened for mining operations. I mention this as an instance of the importance of scientific work, such as it is the object of our Society to promote, which may especially "tend to develop the resources of Australia, and to illustrate its Natural History and Productions."

Then again the geology of the Clarence River series and of the Narrabeen Shale beds requires investigation, and the succeeding Hawkesbury Sandstone formation upon which Sydney stands and whose yellow rock cliffs give such picturesqueness to our coast and harbour scenery and to the valleys in our Blue Mountains

has not been fully explored. Its economic productions of the finest building stones and brick and pottery clay shales are of great value, as the fine public buildings in the city will testify : its geological characteristics and palæontological treasures are of special interest ; though these have for many years engaged the attention of geologists it is but recently that from the rocks of Gosford one of the finest collections of fossil fishes has been brought to light : while, about the same time, the important discovery was made of *Labyrinthodon* remains, which have been described by Professor W. J. Stephens, M.A., and figured in the Proceedings of the Linnean Society. These with similar recent discoveries in the lacustrine Wianamatta shales justify anticipations of further finds of interest.

The next series of strata requiring investigation are those of the so-called Cretaceous age. I say "so-called" for they have been only provisionally assigned to the Cretaceous period, as a portion of the series, notably in Western Australia, may be of Jurassic age ; as yet very little is known about them. They occupy some 40,000 square miles in New South Wales and nearly if not quite half the Australian continent, so that they afford an immense area for examination. They are of great economic importance ; for the strata composing them offer favourable conditions for the occurrence of artesian water, which has been proved, not only in this colony but also in Queensland and South Australia, in bores varying from 110 to 1600 feet deep, splendid water issuing from these, and flowing freely from the pipes, in one instance at a height of 60 feet above the surface of the ground.

Artesian water in this formation was first obtained by Mr. David Brown in 1880, in bores put down close to some "mud springs" which are natural artesian springs on Kallara Station, in the Darling District. Observing from the Geological Map, by the Rev. W. B. Clarke, that this formation extends almost throughout the North Western portion of the colony, I, in conjunction with Messrs. Gilliat and Bruce in 1880, advised the

Government to put down a series of bores for artesian water, with a view of opening up a new and well-watered stock route from Mount Brown Gold Field to Bourke, to lead the northern traffic to the railway terminus at Bourke. These borings have been successful and in the last bore put down near the Paroo, under the direction of Mr. W. H. J. Slee, Superintendent of Drills, a splendid supply of water rising to a height of 30 feet above the surface was struck at a depth of 940 feet. In 1881 Mr H. Y. L. Brown, then one of our geological staff and now Government Geologist of South Australia, examined this portion of New South Wales and reported as to the Cretaceous formation and the certainty of obtaining artesian water in it. Mr. H. C. Russell, Government Astronomer, has also pointed out that the rainfall over the Darling water-shed does not flow away in the river channel but passes underground. In referring to this subject it is right to mention, though I was only lately made aware of the fact, that so far back as 1862 Mr. Richard Bennett, of Victoria, wrote an admirable letter to the *Economist* advocating the search for artesian water in this country.

Mr. R. L. Jack, Government Geologist of Queensland, who has issued a valuable work on the geology of that colony, states that the "Desert Sandstone," so named by Daintree, may be of Cretaceous age and is of so porous a character that it acts like a sponge in absorbing rain-water which issues as permanent springs where it rests upon the impermeable clay beds.

The Cretaceous formation supports good pasturage for sheep, cattle and other stock, but with the exception of a few localities such country, occurring as it does in the arid parts of Australia, is naturally devoid of permanent surface water. So that where most wanted the supply may be obtained from underground sources and by enterprise this dry country may be made to abound in overflowing and inexhaustible wells of good water. The wide scope which nature has afforded for scientific work in the improvement and profitable occupation of this country I need not point out.

The Tertiary formations are perhaps better known than those to which I have already referred. More attention has been given to them on account of the rich gold-bearing, stream tin and diamondiferous deposits which they contain. Nevertheless, not only has very much to be done in the way of elucidating the modes of occurrence of the deposits themselves and the nature of their embedded fossils; but the interest attaching to the work is increased by the discovery, which such work leads to, that the rich deposits are far from being exhausted. Mr. T. W. Edgworth David's geological survey of the Vegetable Creek Tin-field has shown that there are 49 miles of stanniferous deep leads of which only about three miles have been worked out since the commencement of tin mining in 1872. During this period tin ore to the value of £1,975,560 has been raised from the deep leads and shallow drifts in this district. Similar geological observations in reference to the gold as well as the tin bearing deposits have been made by myself and the officers of our Survey in other mining districts, proving that the deep leads will afford employment for miners for many years. These ancient fluviatile deposits have been extensively covered with basaltic rocks, indicating volcanic activity at different times during the Tertiary period. Two of the most remarkable of the points of eruption in New South Wales are Mount Conoblas near Orange, and Ben Lomond in New England. The microscopic examination of our various igneous rocks especially those associated with the occurrence of gold, is at present engaging the attention of the Geological Surveyors. Professor Liversidge has already communicated to this Society the results of some good work in this direction. The subject needs the co-operation of many more observers; and it is one which other microscopists of this Society might readily take up.

Few of the geological periods possess greater scientific interest than the Post Tertiary or Pleistocene. In it the characteristic fauna of Australia enjoyed a flourishing state of existence, as evidenced by the vast number of marsupials, some of gigantic

growth, that lived during this period. Their fossil remains, associated with those of crocodiles, were found in abundance at Cuddie Springs on the Gilgoin Station, near Brewarrina; and recently my geological collector, Mr. Charles Cullea, through the kind permission of Mr. M'Donald of the Myall Creek Station, near Ringer, has obtained from an alluvial deposit a unique and splendid collection of fossil bones which I am sure would more than gladden the eyes of that eminent Paleontologist, Sir Richard Owen, to whom we are so deeply indebted for our knowledge of the interesting life history of the Pleistocene period in Australia.

The question will, no doubt, be asked by many, How is it that such remarkable animals existed in numbers throughout Australia at this period, and that, with the exception of a few species, they have since become extinct? Geology gives the answer, and Astronomy, in reference to the Earth's relation to its orbit, helps to explain it. The alluvial deposits of diluvial origin forming our vast Western Plains; those high terrace banks of gravel along our river valleys; the deeply eroded ravines carved out on the sides of our mountains—all plainly tell of a time of great rainfall since the Pliocene period. The heavy precipitation then covered Mount Kosciusko and other of our Alpine peaks with perennial snow; strong rivers coursed down the valleys, and their flood-waters, reaching the low-lying country and becoming confluent, spread out far and wide over it and deposited their burden of muddy sediment to form the level plains of the western interior, over extensive portions of which the highest floods of to-day never reach, and wells or artificial reservoirs have now to be made to supply water for stock. We all know of the rich pasturage that appears in this country in a favourable season. I have recently had the pleasure of travelling over the "Stony Desert," where the gallant explorer Sturt was so long shut in by the drought. I found its stony character truly described; but the stones were almost hidden from view by the splendid growth of herbage after the late rains; the long grass waved as the wind passed over it, and the whole country was brilliant with wild

flowers. How luxuriant, then, must have been the vegetation in the Pleistocene period, when a great rainfall prevailed for thousands of years. Can we not at once realize how, under these favourable conditions, so many and gigantic animals existed throughout the country ; why crocodiles abounded in the Darling River country, near Brewarrina ; and also how both vegetation and animals gradually died out as the wet climate changed to its present arid condition—just as we now witness, in a small degree, the awful devastation of pasturage and of animal life over the same country when a season of drought comes on and lasts for only one or two years.

It has been said that Astronomy explains the principal cause of these remarkable periodical changes of climate ; and it is believed that our great rainfall period was contemporaneous with the glacial period which has left such marked evidences in the Northern Hemisphere ; during this period the Northern and Southern Hemispheres being alternately glaciated.

Its consideration is one of much importance in Natural History investigations, for without it the origin of the living fauna and flora, as well as of many of the physical features of Australia, cannot be rightly understood. The present animals and plants are the successors, direct descendants in some cases, of those which lived under more favourable conditions of existence during the Pleistocene period. This period, therefore, as I have already said, possesses much scientific interest, and from it are avenues open for research in Geology, Palæontology, Botany, Zoology, Physical Geography, Astronomy, etc., which should command the special attention of Members of this Society.

The phenomena of the Recent period are also of importance for scientific observation, such as the wasting of land surfaces, the widening and erosion of creeks and river channels, the wearing away of coast frontages, and other effects of atmospheric and marine denudation ; sand-drifts by wind, silting up of water courses and harbours, and other modes of transit and deposition of rock material ; the decomposition of rocks and the nature of

soils; the occurrence of corals, shells, and other organic remains;—results of observations upon these would, if recorded, not only enable this Society to diffuse information for the interpretation of phenomena observed in connection with the previous Geological periods, but they would be of practical value in reference to the beneficial occupation of the country by man.

It is only in the Recent deposits that human remains have been found in Australia; so that the advent of man upon this Continent does not appear to be of very ancient date. At Bodalla, a stone hatchet has been found at a depth of fourteen feet below the surface; and at Long Bay, near Coogee, Messrs. T. W. Edgeworth David, and Etheridge discovered a portion of an aboriginal skeleton three feet six inches below the present surface of the ground, and lying upon an old land surface. Two sharpened stones were found under the arms of this skeleton, and several bivalve shells, some of which had not been opened. It is believed to have been buried upon the old land surface, and that at least three feet of soil have since naturally accumulated over it; so that it is probably one of the oldest known human remains. Very little evidence as to the antiquity of man in Australia has yet been obtained; the subject is almost an entirely new one for inquiry, and attention should be given to it without delay, lest the old haunts of the natives should be destroyed by modern settlement.

The subject of Australian Palæontology presents quite as many points of interest to the student as does that of its Geology and other kindred subjects. I shall endeavour to show through a brief reference to the more important established facts how wide a field we have around us for original research in the attempt to fill up the gaps which exist in our "Fossil Record." In doing this I have been aided by my colleague, Mr. Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales.

The lowest fossiliferous bed yet recorded in Australia is the Parara Limestone of Yorke's Peninsular, South Australia, in which Mr. Otto Tepper has discovered trilobites, believed by Dr. H.

Woodward to have an Upper Cambrian facies. In Victoria, Professor McCoy has proved the existence, through the presence of graptolites, of an old fauna analagous to that of Europe and America, and comprised within the great division known to Murchison as the Lower Silurian. To speak more precisely, these fossils probably represent an horizon equivalent to the Llandiello. The same authority has also demonstrated the presence in the Southern Colony of rocks of Upper Silurian age, comprised within the sub-division known as the Wenlock and Ludlow series. In our own Country the Lower Silurian, as *fossil-bearing* rocks, are apparently absent, although they may be probably represented by others of a metamorphic character. On the other hand, the Upper Silurian is widely represented in New South Wales, more particularly in the neighbourhood of Yass, where there are certainly representatives of the Wenlock, or perhaps other divisions of that wonderful formation. In Western Australia and Queensland, rocks of Silurian age have not yet been satisfactorily proved, although it is possible that the gold-bearing series of North-West Australia and the Northern Territory may be of this period. Now, these detached "horizons" exemplify how much remains to be accomplished in proving the existence, or otherwise, of the intermediate groups, and the absolute relation borne by them to similar deposits in other parts of the World.

The Devonian strata of this Continent are even less known than the Silurian. McCoy seems to have satisfactorily established the existence of a Devonian fauna and flora in Gippsland. DeKoninck has to some extent shown the same for New South Wales, through the collections of the late Rev. W. B. Clarke. So far as published data go, Queensland possesses by far the best marked Devonian fauna. Through the surveys of my lamented friend, the late Richard Daintree, C.M.G., and more recently those of Mr. R. L. Jack, the limestones of Burdekin Downs have been well explored, and found to contain a very copious fauna probably representing the Middle Devonian of Europe and North America. The relation of these far widely separated centres of

Devonian life to one another, and their bearing on the correlation of the rocks containing them with those of distant countries opens even a wider field of enquiry than we found presented to us by the Silurian.

On approaching the Carboniferous we meet with a much more easily correlated group of organic remains, although many points in connection with their relation to similar groups abroad require elucidation. Both in New South Wales, Victoria, and Queensland, there is a well marked flora of Lower Carboniferous age, by some considered as Upper Devonian. This is found in the neighbourhood of Stroud in the first named Colony, characteristic of the Avon Sandstones in the second, and the Drummond Range and other localities in the last. All three have plants in common, but the precise relation of this flora to the higher marine Carboniferous beds is not at present apparent. The sequence in New South Wales appears to be the most satisfactory, and it is probably here that the question will be solved. The relation of the Upper and Lower Marine Series is a very close one, the fossils apparently having a mixed Carboniferous and Permian facies, and there is much to be said in favour of referring to these under the one general term of Permo-Carboniferous. The Upper and Lower Coal Measures, alternating with the two sets of marine beds, are peculiar from the absence of any portion of their fauna, and in fact by the general, although not absolute absence of animal remains. The flora of the New South Wales Coal Measures is of particular interest from the great preponderance of the genus *Glossopteria*, and in working out the life history of this plant, it becomes necessary to institute a close comparison with the coal-bearing rocks of South Africa and India. This has to a large extent been accomplished by Dr. Ottokar Feistmantel, but much still remains to be done. Without doubt, the greatest paleontological service which could be rendered to the Geology of New South Wales would be a complete elucidation of the relations of the various divisions of her Carboniferous System one to the other, and to those of other countries; the physical conditions under

which the beds were laid down ; and a limitation of the series in an upward direction, where merging into the succeeding Clarence and Hawkesbury-Wianamatta Series.

Marine Carboniferous beds are known to exist in Western Australia, but too little has yet been accomplished to show their relation to those of Eastern Australia.

The rocks known as the Hawkesbury-Wianamatta, including with them the Clarence Series, possesses a flora of a still stronger Mesozoic type than the Upper Coal Measures, but much yet remains to be done before any determinate views can be arrived at.

The remains of Labyrinthodonts are met with sparingly, and those of fish much more frequently—which seem to bear out the Triassic age assigned to these beds ; but the whole question is at present such an open one, that it may practically be described as new.

Much doubt at present hangs over the relations of the other Mesozoic deposits of Australia. In Queensland and Victoria are Mesozoic coal and plant-bearing strata of doubtful stratigraphical position. In the former Colony we have the Oakey Creek beds, near Cooktown ; those of the Burrum Coal-field, near Maryborough ; and the Ipswich Coal basin. In Victoria is the Bacchus Marsh Sandstone ; the Capes Patterson and Otway series, and the beds of the River Glenelg. All have more or less yielded fossils, and require to have their correct horizons indicated, in which Palæontology will play no mean part. The late Mr. Charles Moore endeavoured to show the existence of almost all the Mesozoic stratigraphical sub-divisions from the Lias upwards. A critical examination of his paper will show that the author was led away by his enthusiasm for the subject, and endeavoured to prove too much on too little data. There is reason to believe, however, that in Western Australia beds probably of Oolitic age do exist. But where they pass into, or what relation they bear to the immense formation occupying so large a part of Central and Eastern Queensland, and South Australia, and which even

occurs in the North-Western corner of our own Colony, is still an open question. This great geological area is generally assigned to the Cretaceous Period. Perhaps it would be better to provisionally term it Cretaceo-Jurassic, pending the investigations, which my very general remarks will show there is more than ample room for. Certain it is that Cretaceous rocks do occur throughout the area I have indicated, as evinced by the writings of McCoy, Etheridge, and other authors. In the meantime we may content ourselves by adopting the convenient general term of "Rolling Downs Formation," suggested by Mr. R. L. Jack for so very debatable a series of beds.

Turn which way we will, there is the same scope for enquiry in every branch of Australian Palæontology. Just as we noticed many undoubted well established horizons in the Paleozoic Series, so in the Tertiary we have cognizance, through the long and patient labours of Profs. McCoy and Tait, and the Rev. J. E. Tenison-Woods, of equally well marked sub-divisions, including the marine Oligocene beds of Hobson's Bay, and the Miocene and Pliocene series extending along the Southern Coast of the Continent from the Gippsland Lakes to and beyond the Great Australian Bight. To the student of Palæontology there are years of study before him, notwithstanding all that has been done in contemplating the relation of the fauna of such deposits to that of the present day, and their correlation with similar forms of life in other lands. In New South Wales and Victoria there is the vast field of enquiry connected with the Palæophytology of the Deep Auriferous and Stanniferous Leads—one hitherto only touched upon, comparatively speaking, by such eminent botanists as Von Mueller and Ettingshausen. The investigations of the former have shown the existence in the Pliocene Gold-drifts of a flora containing numerous extinct forms, some of which have living allies. Marine action must have assisted at times in the formation of these drifts, as evinced by the important discovery of fossils made in the Stawell (Vict.) drifts by Messrs. Bernhard Smith and Norman Taylor. This is a most important point, and

requires further investigation. The large number of still unworked drifts will doubtless yield abundant material for further study and comparison. Perhaps one of the most interesting results yet brought to light, by the study of the ancient life history of Australia, is Baron von Ettingshausen's conclusions respecting the Tertiary Flora, more particularly as elucidated by that of the Stanniferous Deep Leads of the Vegetable Creek District. He states—"There is no doubt that the Tertiary flora of Australia contains, besides the elements of the living flora, also elements of other floras extinct in Australia, but developed now in other parts of the Globe. We have found the same mixture of the elements of the floras in the Tertiary flora of Europe, of America, and of Asia."

In connection with the Post Tertiary Deposits, so many interesting problems present themselves that it is difficult to select them for consideration. There will, however, arise the question of the genesis of the huge extinct Marsupialia, the conditions under which they lived, and the causes of their extinction.

The exploration of our Ossiferous Caverns is but in its infancy, and by investigations carried on judiciously, and more so than in the past, we may hope to throw light upon some of the points raised.

Finally, we come to the advent of Man himself on this Continent, a subject which legitimately comes within the scope of palaeontological enquiry, and one, so far, totally neglected. Within the limits of Australian Geological history, there is probably no subject of such absorbing interest as the earliest history of a fast disappearing race. The solution of this question does not appear to lie in the cave deposits, but rather will be revealed by a careful and thorough examination of the "kitchen-middens" and raised-beaches of the coast, and old burial grounds of the interior.

I have thus briefly directed your attention to the different formations with a view of showing what a wide field lies before us

for geological and palaeontological investigation. And when we remember that in these formations there have been already opened practically inexhaustable stores of nearly all the minerals that are of economic value, should we not be inspired with that zeal for discovery which the exploration of a new country always creates? and is not this zeal increased at the foresight of the establishment of commercial industries which such discovery promotes, and upon which the prosperity of the colony depends? This is no visionary prospect. The late Rev. W. B. Clarke foretold the importance of his discovery of gold many years before Messrs. Hargreaves, Lister, and Tom, practically demonstrated, in 1851, the occurrence of the precious metal in quantity at Lewis Ponds—a discovery which then set alight that unextinguishable fire of enthusiasm in mining and commercial enterprise, which, with increasing vitality, is manifested again and again, and especially so at the present time, when the recent discoveries of silver are fascinating the minds of many. The assurance of our venerated geologist was founded upon a knowledge of the geological character of the country.

Sir Roderic Murchison also, from rock specimens sent from here to England, identified the existence of formations similar to the auriferous rocks of the Ural Mountains, and in 1844 urged the unemployed miners of Cornwall to emigrate to Australia to search for gold.

We all know how the marvellously rich discoveries of gold, amounting to £36,863,717, have since sustained those geological deductions; and the examinations made by the officers of the Geological Surveys of New South Wales and of the other colonies reveal the fact that though the more easily worked shallow alluvial deposits and deep leads have hitherto afforded the principal supplies of gold and are far from being exhausted, yet the auriferous formations with their dykes and reefs, from the denudation of which the alluvial gold has been chiefly derived, are of immense extent, (in this colony alone at least 70,000 square miles) and their

development is in its infancy and will be a lasting source of wealth : it would be well therefore in every way to promote it.

But in addition to gold, New South Wales possesses other rich mineral resources in her large deposits of coal, tin, silver and lead, copper, shale, iron, bismuth, antimony, and sundry minerals including diamonds. Coal stands at the head of our economic minerals, classed according to the value of their annual production. And we may justly give precedence to our immense coal resources, for they are of the greatest commercial and national importance, and in their development lies the success of many industries not only in New South Wales but in the other colonies. This is evident when we consider that of the annual production of coal about 39 per cent. was raised for consumption here, as much as 25 per cent. was exported to foreign ports, and 36 per cent. to intercolonial ports, Victoria alone taking 22 per cent. It has been estimated that the coal seams now worked, if drawn upon at double the present output will last for 2,500 years. What possibilities therefore of future industrial expansion have we not in the development of this great store of mineral wealth ; and as the stability and progress of commerce depend so largely upon the aid of science, do we not see the wide sphere of usefulness that the Royal Society will occupy in taking its proper share in the work of raising this country to the national position that Nature reveals it is destined to attain.

Time will not permit me to refer to other sections of work undertaken by the Society ; but in what I have already said it has been my desire to indicate the ever-widening sphere that lies around us for scientific investigation.

Science is the revealing of Truth in all its aspects. Whether that revelation be the knowledge of a simple mineral, or the great central orb of our planetary system ; the lowest form of vegetable or animal life, or of its highest manifestation in the human mind—a reasoning mind that can bring into subjection natural laws, while it perceives itself to be subject to a higher control—its one aim is Truth.

Truth seekers have many and divergent paths to follow, but a unity of purpose should lead them on. I say *should* lead, for at the present day there is too much disunity of action amongst Science-workers. This is fostered by many who in practice, though perhaps not in theory, deny to workers in certain branches of Science, such as Psychology, fellowship with those in the more material fields of Natural History. This discordancy let it be our constant object to discourage.

The name of Darwin has become a by-word with many who oppose the advance of Science; and we must confess that the same spirit has been retaliated on the part of men of Science.

In the history of Science Charles Darwin will ever stand prominent as one of the greatest apostles of Truth as it is in Nature, and of that principle of growth or evolution which the old Bible, more than any other book, affords illustration of and emphatically teaches.

Darwin in his devotion to Natural History alone, may be likened to a mason engaged in the erection of a portion of a great building, who performed the finest of workmanship without knowing or caring to know the complete design of the Architect. He carried out a certain work, and it stands an imperishable monument of his fidelity and ability.

Darwin's teaching of evolution is in the highest degree exemplified in that greatest of modern facts—the progress of Civilization under the elevating influence of Christianity, aided by Science, Art, Literature and Philosophy, which it is the object of our Society to promote.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 2nd MAY, 1888.

ANNUAL GENERAL MEETING.

C. S. WILKINSON, F.G.S., President. in the Chair.

About forty members were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st March, 1888, was presented by the Hon. Treasurer and adopted:—

GENERAL ACCOUNT.

				RECEIPTS.			£ s. d.			£ s. d.					
Subscriptions	{	One Guinea	...	...	...	253	4	0	}	645	15	0		
		Two Guineas	...	...	...	344	8	0						
		Arrears	...	...	...	45	8	0						
Entrance and Composition Fees				...	...				60 18 0					
Parliamentary Grant on Subscriptions															
and Entrance Fees received during															
1887				...	...	...	...	...				424	8	0
Rent of Hall				...	...	...	...	...				95	8	6
Sundries				...	...	...	...	...				12	6	5
Total Receipts				...	...	...	...	...				£1,238	5	11
Balance on 1st April, 1887				...	...	...	...	...				20	17	0
													£1,259	2	11
				PAYMENTS.						£ s. d.					
Advertisements				25	0	0
Assistant Secretary...				...	...	...	...	...	...	...	...	250	0	0
Books and Periodicals				...	...	...	...	...	...	...	...	167	19	9
Bookbinding...				...	...	...	...	...	...	...	...	43	8	5
Freight Charges, Packing, &c.				...	...	...	...	...	...	...	...	14	11	8
Furniture and Effects				...	...	...	...	...	...	...	...	1	11	6
Gas				...	...	...	...	...	...	...	...	17	8	9
Housekeeper...				...	...	...	...	...	...	...	...	10	0	0
Insurance				...	...	...	...	...	...	...	...	10	16	7
Prize Essay Award				...	...	...	...	...	...	...	...	25	0	0
Postage and Duty Stamps				...	...	...	...	...	...	...	...	45	10	0
Petty Cash Expenses				...	...	...	...	...	...	...	...	16	10	7
Carried forward				...	...	...	...	...	...	...	...	637	12	3

PAYMENTS—continued.						£	s.	d.
Brought forward	...	...	...	...	...	637	12	3
Printing	...	...	...	...	...	42	11	2
Printing and Publishing Journal	...	...	...	...	...	210	1	8
Rates	...	...	...	...	...	27	9	0
Refreshments, &c., at Meetings	...	...	...	...	...	11	4	0
Repairs	...	...	...	...	...	46	5	11
Stationery	...	...	...	...	...	3	15	5
Sundries	...	...	...	...	...	28	2	0
Total Payments	...	...	...	...	...	£1,007	1	5
Transfer to Building and Investment Fund	...	...	...	...	...	192	3	0
Balance on 31st March, 1888—								
{ Union Bank						£49	18	6
{ Cash in hand						10	0	0
						59	18	6
						£1,259	2	11

AUDITED—H. O. WALKER.

HARRIE WOOD.

ROBERT HUNT, *Honorary Treasurer.*

W. H. WEBB, *Assistant Secretary.*

SYDNEY, 22nd April, 1888.

BUILDING AND INVESTMENT FUND.

RECEIPTS.						£	s.	d.
Donations	...	...	...	...	...	1	1	0
Parliamentary Grant on Balance of Donations received during 1886	...	...	...	...	...	7	7	0
Interest on Fixed Deposit...	...	...	...	...	...	8	15	0
Total Receipts	...	...	...	...	...	17	3	0
Transfer from General Account	...	...	...	...	...	192	3	0
Balance on 1st April, 1887	...	...	...	...	...	175	5	1
						£384	11	1
PAYMENTS.						£	s.	d.
Fixed Deposit in Union Bank	...	...	...	...	...	384	11	1
						£384	11	1

AUDITED—H. O. WALKER.

HARRIE WOOD.

ROBERT HUNT, *Honorary Treasurer.*

W. H. WEBB, *Assistant Secretary.*

SYDNEY, 22nd April, 1888.

CLARKE MEMORIAL FUND.

	£	s.	d.
Amount of Fund on 1st April, 1887	266	10	9
Interest accrued to 31st March, 1888	10	11	0
	£267	1	9

	£	s.	d.
Fixed Deposit in Union Bank	236	17	0
Balance due from Oriental Bank... ..	30	4	9
	£267	1	9

AUDITED—H. O. WALKER.
HARRIE WOOD.
SYDNEY, 22nd April, 1888.

ROBERT HUNT, *Honorary Treasurer.*
W. H. WEBB, *Assistant Secretary.*

SMITH MEMORIAL FUND.

	£	s.	d.
Amount of Fund on 1st April, 1887	112	6	6
Interest on Fixed Deposit	6	14	4
	£119	0	10

	£	s.	d.
Amount remitted for Painting	110	0	0
Balance in Union Bank	9	0	10
	£119	0	10

AUDITED—H. O. WALKER.
HARRIE WOOD.
SYDNEY, 22nd April, 1888.

ROBERT HUNT, *Honorary Treasurer.*
W. H. WEBB, *Assistant Secretary.*

Messrs. J. T. Wilshire and P. N. Trebeck were elected Scrutineers for the election of officers and members of Council.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year :—

Honorary President:

HIS EXCELLENCY THE RIGHT HON. LORD CARRINGTON, G.C.M.G.

President:

SIR ALFRED ROBERTS.

Vice-Presidents:

H. C. RUSSELL, B.A., F.R.S.

C. S. WILKINSON, F.G.S., F.L.S.

Hon. Treasurer:

ROBERT HUNT, F.G.S., &c.

Hon. Secretaries:

PROF. LIVERSIDGE, M.A., F.R.S., &c.

F. B. KYNGDON.

Members of Council:

W. A. DIXON, F.C.S., &c.

P. R. PEDLEY.

A. LEIBIUS, Ph. D., M.A., F.C.S.

PROF. THELFALL, M.A. (Cantab.)

CHARLES MOORE, F.L.S.

PROF. WARREN, M.L.C.E.

The following gentlemen were duly elected ordinary members of the Society :—

O'Neil, G. Lamb, M.B., C.M., *Edin.* ; Sydney.

Smith, Charles Atkinson, F.C.S., F.I.C. ; Sydney.

Thring, Edward T., F.R.C.S. *Eng.*, L.R.C.P. *Lond.* ; Petersham.

The certificates of two new candidates were read for the second time, and of three for the first time.

The names of the Committee-men of the different Sections were announced, viz. :—

MEDICAL SECTION. { Chairman ... Dr. Knaggs.
Secretaries .. Dr. MacCormick and Dr. Jenkins.
Committee... Dr. W. Chisholm, Dr. Crago, Dr. E. Fairfax Ross, Dr. Hankins, Dr. W. H. Goode, Dr. P. Sydney Jones.

Meetings held on the Third Friday in each month, at 8.15 p.m.

MICROSCOPICAL SECTION. { Chairman ... F. B. Kyngdon.
Secretary ... Percy J. Edmunds.
Committee... H. G. A. Wright, M.B.C.S.E., H. O. Walker, S. MacDonnell, and Dr. Morris.

Meetings held on the Second Monday in each month at 8 p.m.

SANITARY SECTION. { Chairman ... J. Trevor Jones, C.E.
Secretary ... Reuter E. Roth, M.B.C.S.E.
Committee... R. Hunt, Dr. W. Chisholm, E. E. Sager, W. A. Dixon, F.C.S., Dr. Ashburton Thompson, J. B. Henson, C.E.

Meetings held on the Second Tuesday in the month at 8.15 p.m.

The following letter was read from the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.:—

533 Elizabeth Street, Sydney,
5th March, 1888.

To C. S. Wilkinson, Esq., F.L.S., F.G.S.,

President of the Royal Society of New South Wales.

My dear Sir,

I have the honour to acknowledge the receipt of your letter and medal, conveying to me the Society's award of the Clarke Medal for this year. In thanking the Society for this distinguished mark of their estimation, I feel myself quite inadequate to express my sense of the honour thus conferred upon me.

If any services that I have rendered to Science were deserving of a reward this more than amply satisfies my greatest anticipations, and I trust it will be a new stimulus to exertion.

I regret exceeding that my present state of health prevents me from taking a more active part in the labours of the Society, but I have every hope and confidence that I shall yet be able to labour for its interests, and I shall ever consider myself honoured by being associated even in the humblest way with its labours.

Pray convey my warmest thanks to the members of the Council, and believe me, Mr. President

Yours very faithfully,

J. E. TENISON-WOODS.

Mr. C. S. Wilkinson, F.G.S., F.L.S., President, then read his address.

A vote of thanks was passed to the retiring President, and Sir Alfred Roberts was installed as President for the ensuing year.

EXHIBIT.

Mr. Lawrence Hargrave exhibited a compressed air engine for driving a flying-machine, describing it as follows:—the cylinder is $1\frac{1}{4}$ inches diameter and the stroke is 2 inches: the engine weighs 2 lbs 7 oz. The receiver for the compressed air is '21 cubic feet capacity, made of $\frac{1}{8}$ inch steel, single rivetted, and brazed: the bursting pressure is about 900 lbs per square inch: the working pressure will be 500 lbs per square inch, and the reduced pressure 100 lbs per square inch; and there will be 9,200 foot-pounds available for work: this power will have to be expended in from half to three-quarters of a minute. The charged receiver weighs 6 lbs 12 ozs. A small Richard's indicator has been made for adjusting the piston valve. The wood and paper work will weigh about 2 lbs. The machine is intended for a flight of 200 yards. As it will be some time before the whole of the apparatus is in a condition to offer to this Society in the form of a paper, anyone wishing to assist in the development of artificial flight may have a tracing of the working drawing now, and make sketches of the deviations: and from these a double sized machine could be made introducing more steel and less brass, and using triple expansion with a receiver pressure of 1,500 lbs, and a factor of safety of 2. I am indebted to Mr. James Richard Thomson for much information that has been of great assistance to me.

The following donations received since the last meeting were laid upon the table:—

LIST OF DONATIONS RECEIVED SINCE DECEMBER 7TH, 1887.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

- ABERDEEN**—University. Catalogue of the General Library, Vols. i. and ii., and Supplement 1878—87. Catalogue of the Library, Vol. iii., Law Medicine, 1874. *The University.*
- ADELAIDE**—Forest Flora of South Australia, Part 8. *Government Printer, S.A.*
- Royal Society, Transactions of the Intercolonial Medical Congress of Australasia, First Session held in Adelaide, S.A., August to September, 1887. *The Society.*
- University. The Adelaide University Calendar for the Academic Year 1888. *The University.*
- AGRAM**—Société Archéologique. Vjestnik hrvatskoga Arheološkoga Društva, Godina ix., Br. 4, 1887; x., Br. 1, 1888. *The Society.*
- AMSTERDAM**—*Revue Coloniale Internationale*, Tome v., Nos. 5 and 6, November and December, 1887. *The Editors.*

- AUCKLAND**—Auckland Institute, and Museum. Report for 1887—88. *The Institute.*
- ANNAPOLIS (MD.)** United States Naval Academy. Annual Register, Thirty-eighth Academic Year 1887—88. *The Academy.*
- BALLAARAT**—The Ballaarat School of Mines, Industries and Science. (In the University of Melbourne.) Annual Report for 1887. *The School of Mines.*
- BALTIMORE**—Johns Hopkins University. American Chemical Journal, Vol. ix., Nos. 1 and 2, 1887. American Journal of Mathematics, Vol. ix., Nos. 2 and 4, 1887. American Journal of Philology, Vol. vii., Part 4, 1886; Vol. viii., Part 1, 1887. Historical and Political Science, Fifth Series, Nos. iv.—vii., 1887. University Circulars, Vol. vi., Nos. 56 and 57, 1887. *The University.*
- BERGEN**—Museum. Aarsberetning for 1886. *The Museum.*
- BERLIN**—Königlich Preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 40—52, 22nd October to 17th December, 1885; Nos. 19—39, 14th April to 28th July, 1887. *The Academy.*
- Königl. Preuss. Meteorologisches Institut. Ergebnisse der Meteorologischen Beobachtungen im Jahre, 1886. *The Institute.*
- BERNE**—Société de Géographie de Berne. Jahresbericht, Vol. viii., 1885 to 1887. *The Society.*
- Schweiz Departement des Innern. Graphische Darstellung der Schweizerischen hydrometrischen Beobachtungen, Bl. i., ia., ib., ii., iia., iib., iii., iv., v., vi. *The Department.*
- BIRMINGHAM**—Birmingham and Midland Institute. Programme for Session 1887—88. Report of the Council for the year 1887. *The Institute.*
- Birmingham Philosophical Society. Proceedings, Vol. v., Part 2, Session 1886—87. *The Society.*
- BOLOGNA**—R. Accademia delle Scienze dell' Istituto di Bologna. Memorie, Serie iv., Tome vi., 1884, and vii., 1886. *The Academy.*
- BRAUNSCHWEIG**—Vereins für Naturwissenschaft. Jahresbericht, Vol. v., 1886 bis 1887. *The Society.*
- BRISBANE**—Acclimatisation Society of Queensland. Catalogue of Plants in the two Metropolitan Gardens, the Brisbane Botanic Garden and Bowen Park, by F. M. Baily, F.L.S. List of Plants usually available for Distribution at the Acclimatisation Society's Gardens, Bowen Park, Brisbane. „
- BRISTOL**—Bristol Naturalists' Society. Proceedings, New Series, Vol. v., Part 2, 1886—7. Annual Report for the year ending 30th April, 1887. „
- CALCUTTA**—Asiatic Society of Bengal. Journal, Vol. liv., Part ii., No. 4, 1885; Vol. lv., Part ii., No. 5, 1886; Vol. lvi., Part ii., No. 1, 1887. Proceedings, Nos. 6, 7, 8, June, July, August, 1887. „

D—May 2, 1888.

CALCUTTA—Continued.

Geological Survey of India. A Manual of the Geology of India, Part iv. Mineralogy, 1887. Memoirs of the Geological Survey of India, Vol. xxiv., Part 1, 1887. Memoirs (Palæontologia Indica), Series x., Vol. iv., Part 3, 1887. Records, Vol. xx., Part 4, 1887.

The Director.

CAMBRIDGE—Cambridge Philosophical Society. Proceedings, Vol. vi., Parts 2 and 3, 1887.

The Society.

CAMBRIDGE (MASS.)—Museum of Comparative Zoölogy at Harvard College. Annual Report of the Curator for 1886-87. Bulletin, Vol. xiii., Nos. 5 and 6, 1887. Memoirs, Vol. xvi., Nos. 1 and 2, 1887.

The Museum.

Psyche, Vol. v., Nos. 141-142, Jan.-Feb., 1888.

The Editor.

CHARLOTTESVILLE, VA. University of Virginia. Annals of Mathematics, Vol. iii., Nos. 4 and 5, 1887.

The University.

CINCINNATI—Cincinnati Society of Natural History. Journal, Vol. x., No. 4, Jan., 1888.

The Society.

COPENHAGEN—Société Royale des Antiquaires du Nord. Mémoires, Nouvelle Série, 1887. Tillæg til Aarbøger for nordisk Oldkyndighed og Historie Aargang, 1886.

„

CORDOBA—Academia Nacional de Ciencias.—Actas, Tomo v., Entrega Tercera, 1886.

The Academy.

DRESDEN—Königlich Sächsische Statistische Bureau. Statistische Mittheilungen über die Grundstücken-Zusammenlegungen im Königreiche Sachsen vom Jahre, 1833, bis zum 30 Juni, 1887. [Supplement heft zur Zeitschrift, xxxiii., Jahr., 1887.]

The Bureau.

DUBLIN—Royal Geological Society of Ireland. Journal, Vol. xviii., Part 2, New Series, Vol. viii., Part 2, 1886-1887.

The Society.

EDINBURGH—Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. iii., No. 12, 1887; Vol. iv., Nos. 1, 2, 3, 1898.

„

FLORENCE—Società Africana d' Italia (Sezione Fiorentina). Bullettino, Vol. iii., Fasc. 7, 1887, Fasc. 8, 1888.

„

Società Entomologica Italiana. Bullettino, Vol. xix., Trimestri 3 & 4, 1887.

„

GEELONG—Gordon Technical College. Constitution and Progress Report, 1887.

The College.

GÖTTINGEN—Königl. Gesellschaft der Wissenschaften und der Georg-Augusts-Universität. Nachrichten, Nos. 1-20, 1886.

The Society.

HALIFAX—Nova Scotian Institute of Natural Science. Proceedings and Transactions, Vol vi., Part 3, 1884-5.

The Institute.

HAMBURG—Deutsche Meteorologische Gesellschaft. Meteorologische Zeitschrift, Heft 11 and 12, 1887; Heft 1, 2 and 3, 1888.

The Society.

HAMBURGH—*Continued.*

Deutsche Seewarte. Aus dem Archiv der Deutschen Seewarte, vii., Jahrgang, 1884. Deutsche Ueberseeische Meteorologische Beobachtungen, Heft 1, 1883-87. Meteorologische Beobachtungen in Deutschland, für 1878-1885, Jahrgang, i.-viii., incl. Resultate Meteorologischer Beobachtungen von Deutschen und Holländischen Schiffen für Eingradfelder des Nordatlantischen Ozeans, Nos. i.-vii., 1880-1887. *The Observatory.*

Geographische Gesellschaft in Hamburg. Mittheilungen, Heft iii., 1885-86. *The Society.*

Naturhistorisches Museum zu Hamburg, Bericht für das Jahr., 1886. *The Museum.*

HARLEM—Société Hollandaise des Sciences. Archives des Sciences Exactes et Naturelles, Tome xxii., Liv. 2 and 3, 1887. *The Society.*

HEIDELBERG—Naturhistorisch Medicinischer Verein. Verhandlungen, Neue Folge, Band iv., Heft 1, 1887. „

HOBART—Royal Society of Tasmania. Abstract of Proceedings, 21st Nov. 1887. „

IOWA CITY—Iowa Weather Service. Report for the year 1886. *The Director.*

JENA—Medicinisch Naturwissenschaftliche Gesellschaft. Jenaische Zeitschrift, Band xxi., N.F. Band xiv., Heft 1 to 4, 1887. *The Society.*

KIEFF—Société des Naturalistes de Kieff. Mémoires, Supplément au Tome viii., 1887. „

LEIPZIG—Königlich Sächsische Gesellschaft der Wissenschaften. Berichte über die Verhandlungen, Mathematisch-Physische Classe, Nos. i., ii., 1887. „
Vereins für Erdkunde. Mittheilungen, Heft 1, 2 and 3, 1886. „

LIEGE—Société Royale des Sciences. Mémoires, Série 2, Tome xiv., 1888. „

LONDON—Geological Society. List of the Geological Society of London, Nov. 1, 1887. Quarterly Journal, Vol. xliii., Part 4, No. 172, Nov. 1, 1887; Vol. xliv., Part 1, No. 173, Feb. 1, 1888. „

Institution of Naval Architects. Transactions, Vol. xxviii., 1887. *The Institution.*

Iron and Steel Institute. Journal, No. 2, 1887. „

Linnean Society. Journal—Botany, Vol. xxiii., Nos. 152-154, 1887; Vol. xxiv., Nos. 160, 161, 1887. Zoology, Vol. xx., No. 118, 1887; Vol. xxi., No. 130, 1887; Vol. xxii., Nos. 136-138, 1887-8. List of the Linnean Society of London, Session 1887-1888, Dec., 1887. *The Society.*

LONDON—Continued.

- Meteorological Office. Hourly Readings, Part iv., Oct.-Dec., 1884, Official No. 70; Part i., Jan.-Mar., 1885, Official No. 74. Monthly Weather Report, December, 1886, Official No. 68. Quarterly Weather Report, Part iv., Oct.-Dec., 1878, Official No. 55; Parts i. and ii., Jan.-June, 1879, Official No. 49. Weekly Weather Report, Vol. iv., Nos. 12-45, 28th Mar.-14th Nov., 1887. Quarterly Summary of Ditto, Vol. iv., Appendix 1, 1st, 2nd, and 3rd Quarters. *The Meteorological Office.*
- Pharmaceutical Society of Great Britain. Calendar, 1888. Journal and Transactions, Vol. xviii. (Third Series), Parts 208-210, Oct.-Dec., 1887; Part 211, Jan., 1888. *The Society.*
- Quekett Microscopical Club. Journal, Ser. ii., Vol. iii., No. 20, Dec., 1887. *The Club.*
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FOREST DESTRUCTION IN NEW SOUTH WALES AND ITS EFFECTS ON THE FLOW OF WATER IN WATER-COURSES AND ON THE RAINFALL.

By W. E. ABBOTT, Wingen.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

IN July, 1880, an essay which I wrote on "Ring-barking and its Effects," was read before this Society, and will be found in the Journal for that year. My object now is to lay before the members of the Royal Society, and place on record for future use, the results of observations and experiments which I have made on the same land, and on land adjoining that of which I then wrote. In my former essay I showed what had been the effect during a period of ten years of destroying the natural forest growth on some land of my own in the watershed of the Upper Hunter River, and what had been the general effect of ring-barking in that part of New South Wales for a period of about twenty years. The land of which I wrote is situated about twelve miles south-east of Murrurundi, on the Page River, a small tributary of the Hunter, has been in the possession of my family for more than forty years, and has been under my personal observation since I was old enough to observe anything. Writing in 1880, I showed that from 1847 to 1870 all the small creeks—and they are very numerous on this estate—had been dry water-courses never containing any water except for a short time after rain had fallen, and never running permanently throughout the summer no matter how favourable the season might be. In 1869, '70, and '71, a considerable portion of the land was ring-barked for the purpose of sweetening and improving the grass, but without any idea of what the effect might be on the flow of water in the creeks or water-courses or on the rainfall. At that time, as now, many of the wise men of New South Wales told us that the effect of destroying the forest growth would be to dry up the springs and rivers, and reduce the rainfall of the country. We were told that this had been the invariable result of forest destruction in Europe and in America, and must be the inevitable effect of such action here. We were urged to conserve the forests already in existence, and plant the great western plains of New South Wales with trees for the purpose of increasing the annual rainfall and the natural water supply. A late President of this Society

and a very eminent scientist, perhaps the most eminent in his own line that has yet appeared in Australia, was among the chief exponents of these views. It was then, and seems now to be generally accepted that it is the trees that produce the rain, and not the rain that produces the trees, and yet it seems to me that a very little thought will show the converse of this to be true. Rain may fall and does fall in the absence of forests, but it would be somewhat difficult for the forests to grow unless the rain fell first.

The results of forest destruction at Glengarry, on the Page River, were very remarkable, and similar results have followed in a greater or less degree in all cases that have come within my knowledge in the watershed of the Hunter River.

All the dry water-courses or creeks that were of any size in the ring-barked country became permanently flowing streams, and even in the small gullies less than half a mile in length springs broke out which are fairly permanent in most seasons. So that a country which from 1847 to 1870 was without any water except that contained in the Page River on the frontage, after having the forest destroyed became so watered throughout its whole extent, that one cannot go in any direction for more than half a mile without coming across running water.

And these springs and permanently flowing rivulets that were produced on Glengarry by the destruction of the forests about the year 1870 have remained permanent ever since, notwithstanding the severe and very protracted droughts through which we have passed in the last eighteen years. Of course they have been affected by the droughts, and the quantity of water in them very much reduced as has been the case with all sources of water supply in the Colony; but even in the most severe drought, which ended here in March, 1886, the supply of water in these rivulets and springs was ample for all purposes. The drought which ended here in the beginning of 1886 was, as shown by the rainfall records of the Government Observatory, one of the most severe experienced since the Settlement of the Colony, or at any rate since records have been kept, and the chief characteristic of this drought was the unusually long run of dry years in which the rainfall at almost all the recording stations throughout the Colony was below the average for each place.

In this part of the country there has not been any rainfall record kept farther back than 1870, and my own record only goes back to 1876; but there is on one of the mountains on Glengarry what may be regarded as a natural drought-gage. Very nearly on the top of the Lagoon Mountain, there is a lagoon or small lake at an elevation of over 3,000 feet above sea level, about 70 yards in length and of considerable depth. This lagoon has a

very small drainage area and was dry some time between 1848 and 1851, and never dried up again until the end of 1885. The whole of the country on the Lagoon Mountain remains in the same state now as in 1848 and previous years, or since it was first occupied. Here we have, I think, in the absence of any regularly kept records of rainfall, tolerably good proof that the drought which ended in the beginning of 1886 was at least as severe as anything experienced in the 40 years previous, and yet the rivulets and springs which we may say were artificially produced withstood its utmost severity.

My reason for placing these facts before you now, is to point out that the extremely remarkable results which followed forest destruction on Glengarry have not been of a temporary character, and have not been due to a coincident change in the seasons. When I wrote last, I placed before the members of this Society the results of some measurements of the permanent flow of water in three water-courses, which had begun to flow immediately the natural forest growth had been destroyed, and which previously as far back as any knowledge of them could be obtained had been dry water-courses. These measurements had been carefully made by myself, without regard to the flood water or freshets after rain, and gave the permanent flow of water averaging the three water-courses at about one-fortieth of the rainfall, and the measurements were made after a somewhat dry period. The whole of the water shown by these measurements was evidently additional water to that which would have been found in these water-courses before the forests were destroyed, though they did not show the whole of the additional water. From that time up to the present all these streams have continued to flow, and though they were much reduced in volume towards the end of 1885, they did not fail to give an ample supply of water for all purposes even after the Page River had stopped running in many places. In addition to this, over a large area of country which I have had ring-barked since 1880, precisely similar results to those first recorded have followed. It is generally held, I believe, that the surest test of scientific knowledge is that we shall be able to predict beforehand the results that will follow from certain combinations, forces put in operation, or work done.

Now, I think, with the mass of evidence ready to our hands, which has been accumulating in many parts of the Colony during the last thirty years, it is quite possible to predict with absolute certainty that in any given case where the character and general fall of the country is such that an extra supply of water in the ground would make its presence apparent in the water-courses, the effect of destroying the natural eucalyptus forests will be to cause a permanent increase of water in such water-courses, and

produce springs where there were none before. I have myself fenced in dry country, and afterwards produced permanently running streams by simply ring-barking the trees, and this I have been able to do because the country was in all respects similar to other country which had been operated on before.

Of course, the geological formation as well as the contour of the country has much to do with the question, whether deforestation in any given case will produce surface water or not. In many parts of the country where there are deep-lying beds of sand or gravel, an increased flow of water produced by ring-barking would not make itself apparent on the surface or in the water-courses or creeks. The volume of underground water would be increased, but not sufficiently to bring it to the surface of even as high as the beds of the creeks, and the increased volume would find its way to the main rivers by the old underground channels. The country upon which I have operated consists of basaltic ranges and valleys, some of the ranges of considerable elevation covered principally with white box timber, a species of eucalyptus not hitherto noted for very rapid growth or for any unusual power of withdrawing moisture from the soil. The height above sea level varies from about 1,300 feet to about 2,500 feet. The distance due east from the sea coast is from 70 to 80 miles; latitude $31^{\circ} 55'$, longitude $150^{\circ} 50'$. In no case is there any sand or gravel in the formation, but in other parts of the Colony I have known ring-barking to produce water in sandstone and gravelly country. The soil is not very deep, varying from two to three feet to about twenty feet, and the creeks all run on the basaltic bottom rock. It is a centre of long continued volcanic disturbance, surrounded on all sides by the older coal measures tilted against the volcanic ranges at various angles of inclination and broken up in every direction.

It may be thought that my experience is exceptional, and it will no doubt be asserted that the change which has come over the country which I hold since the forests were destroyed is due to other and unknown causes. The facts which I have given here are undeniable and may be verified any day, and I do not think my experience is exceptionable. It certainly is not in this part of the Colony, and I have made inquiry in many parts of New South Wales, and found in nearly all cases that the result of ring-barking was to increase the flow of water in the water-courses and cause the outburst of fresh springs. In one case on the Upper Namoi River, where ring-barking did not apparently increase the flow of water in the creeks, the banks of the river in many places just above water level became boggy, showing an additional inflow of water, which I think accounts satisfactorily for the non-increase in the smaller water-courses. The formation

there differed from that at Glengarry, and the increased volume of water in the ground caused by ring-barking evidently found its way to the main river channel through the lines of stratification, or through underground sand or gravel beds. Where this does not occur, and where the country is mountainous or undulating, the result of destroying the eucalyptus forests in New South Wales is I think invariably to produce an increased flow of water in the water-courses, and to cause springs of water to appear where before there were none.

With reference to the theory that growing forests attract the clouds, and so cause rain to fall in their immediate neighbourhood when without their presence it would not have fallen, I will not say much. Our present knowledge of the causes, apart from prevailing winds which determine the rainfall of any particular place from year to year, and make one year differ from another year, and one series of years differ from another series of years, is vague and indefinite in the extreme. We know that winds coming from certain directions generally but not invariably cause rain to fall or are accompanied by a fall of rain, and that winds from other directions are generally accompanied by dry weather, and we can make some sort of a guess why this should be so, but why the wind should blow more constantly from one direction one year, and from a different direction another year, we are unable to tell. No one, I am sure, will contend that the direction, force, and quantity of wind from year to year, can possibly be determined by forest growth or forest destruction at any particular place. The changes are far too rapid to be accounted for in this way, and the extent of sea and land over which a steady wind, lasting even for a week, will have travelled is so great that it cannot be accounted for by the local conditions of any one country or even of any one continent. If this be so, when we assert that by cutting down a few trees we are reducing the rainfall, or that by planting a few trees we are increasing the rainfall, are we not acting in much the same way as the fly which perched on the waggon wheel and exclaimed in exultation, "See what a dust I am making."

The rainfall records kept at Paris, and covering about two centuries, show no decline in the rainfall of that place, though the changes which man is capable of producing have been there very great within the time covered by the record. Some records in the Eastern States of America cover more than a century, and show no sign of any decline in the average rainfall, although in those States during the time over which the record extends, the amount of forest destruction going on has been greater than in any other part of the World. These records, like all others that have been kept for a sufficiently long period, vary

very much within not very well defined limits, always swinging back as it were but with the greatest possible irregularity, and the changes are not coincident either in time or sequence with any known local terrestrial or cosmical changes which might be supposed to have produced them. The reason of our inability to forecast the rainfall of any particular place, even for one year or one day, must be that the causes which determine such rainfall are infinitely numerous, and their interaction on each other so complicated that results are very rarely repeated. If this were not so, we would before now have gained even a little foothold of safe standing ground. As the ages roll on, if civilization and progress continue, gradually accumulated records and experiences may enable the scientist of the future to do what for us is impossible, but at present I am afraid the outlook is not hopeful. Our work is to accumulate the records and experiences.

Of course it may be contended that rainfall having been determined by other remote and complicated causes, might be slightly increased or reduced in quantity by the presence or absence of growing trees at any particular place. To prove or disprove this is impossible, until we are able to say beforehand in the presence or absence of trees what would have been the exact rainfall of any particular place on the earth's surface for any year or any series of years. In the absence of any such knowledge one way or the other, I think we may safely consider our convenience, and disregard even this much modified claim, which is by no means what is usually meant when people assert that forest destruction causes drought. There is one line of inquiry which I have often thought might possibly, if patiently and laboriously followed up, lead to some practical result in the way of enabling us to make some approach to the prediction of seasons for any particular place. It has not yet as far as I know been tried. With the most careful research, the finest instruments, and the greatest intelligence which the nineteenth century has produced, we cannot find for any given place in the varying records of the occurrence of droughts and floods, any order or sequence which will enable us to predict the season even for one year or one day in advance, or to say whether the coming year will be a year of drought or of flood; yet there may be a way different from that generally tried by which such knowledge might in some measure be gained. The attempt to find a *saros* for the seasons, like that discovered by the Chaldean priests for the moon's changes, has always failed, and there does not seem to be now even the slightest indication that such a thing will ever be found; but though we cannot predict the changes of the seasons for a century in advance as the moon's changes of position may be predicted, yet there may be a possibility of our attaining

knowledge sufficient to enable us to predict the seasons for a considerable time, perhaps more than a year.

I think it will be generally admitted that the total amount of heat which the earth with its atmosphere receives from the sun each year, is so nearly the same that there is no appreciable difference. Unusually cold summers or warm winters at any one place may be accounted for, and are accounted for by the varying distribution of heat on the earth's surface, caused by atmospheric and oceanic currents, but they do not affect the total of heat units. This being so, it follows that the amount of work done by the sun's heat falling on the surface of the earth, of lakes, of rivers, and of the ocean, in raising water by means of evaporation, and holding it suspended in the atmosphere, must be the same from year to year. Our atmosphere at a given temperature, or to put it in another form, charged with a given amount of heat, is only capable of holding in suspension a certain fixed proportion of water, so that after the point of saturation is reached, if the temperature be reduced, some of the water in some form must return to the surface of the earth or sea.

Now if the quantity of heat received by the earth be the same from year to year acting on the same surfaces of sea and land, will it not raise by evaporation precisely the same amount of water each year. If our atmosphere be only capable with the same amount of heat each year of holding in suspension the same quantity of water, is it not certain that there will be a like surplus in the various forms of rain, hail, and snow, to return again to the earth's surface each year. If this be admitted, it follows with absolute certainty that the total rainfall of the earth's surface, if under this designation we include all the forms in which water is deposited from the atmosphere, must be precisely the same from year to year, or can only vary within scarcely appreciable limits. Though we may not be able to say what the total rainfall of the earth amounts to, we may be fairly sure that it does not vary much if at all. This being so, it will follow that an excess of rainfall—a flood year—in any one part of the World must produce a deficiency of rainfall—a drought—in some other part of the World, or it may happen that a very slight reduction of the general rainfall may supply the excess which produces the local flood.

We cannot tell which of these explanations is true at present, but if the first be the correct one, we may possibly by comparing the rainfall records for different parts of the World, and over long periods of time, be able to find out in what particular places the droughts and floods compensate each other, and in what order of time; in fact, we may be able to say where our surplus rainfall comes from when we have a flood year, and where the proportion of our rainfall that is deficient has gone when we have a drought year. Such knowledge, if attained, would perhaps enable us to

predict the seasons for even more than a year, and would certainly be a valuable addition to the science of meteorology. The opinion which is prevalent in many parts of this Colony, that a droughty year in Europe will be followed here by a droughty year within a given time, seems to indicate a glimmering consciousness of some such connection as I have endeavoured to trace out.

In conclusion, I will say that for many years I have endeavoured to find upon what evidence rests the popular opinion that forest destruction reduces the rainfall of any country and dries up springs. I have seen many cases quoted where the occurrence of a severe drought was shown to be coincident with the destruction of forest in some particular place, but that would not prove anything, unless it could also be shown that droughts did not occur before the forests were destroyed, and would not have occurred if the forest had not been destroyed, and this part of the proof is always wanting. That large forest growths have been destroyed in many places without reducing the rainfall or the flow of water in the streams we have the most undeniable proof, but I do not think there is a single case recorded in the whole World where an accurately kept record of rainfall and flow of water in streams, or of either, shows a permanent diminution coincident in time and corresponding in degree with the gradual diminution of forests. That there is a connection between rainfall and forest growth there can be no doubt, nor can we doubt that they stand to each other in the relation of cause and effect, but the popular belief has reversed the order of this relation, holding the forest to be the cause of rainfall when it is in reality one of the effects of rainfall. From the well known power of the eucalyptus tribe to dry up swampy places, which has been made use of both in Europe and America, we might expect that the result of forest destruction where the trees were of this order would be much more decided and more quickly apparent, than where the trees were of a different kind like those of Europe or America, but the difference is, I think, only a difference in degree not in kind. In both cases the life of the tree is maintained in the same way, and we ought to find that forest destruction in Europe or America produced results similar in character to those produced in Australia, though perhaps they might differ in degree. For these reasons, I think, it is now time that those teachers of science in Europe and America, who hold by and teach the popular theory that forests do cause increased rainfall and an increased flow of water in springs and water-courses, and that deforestation does reduce the rainfall and flow of water in springs and water-courses, should reconsider their theory and the evidence on which it rests. This seems to me very necessary in the light of the experience gained in Australia, where forests are destroyed wholesale for pastoral purposes.

DISCUSSION.

Mr. F. B. GIPPS:—Mr. Abbott has entertained us with a most interesting paper on the effects of ring-barking or deforestation, which is the more valuable on account of its being the result of actual observation. If another such enthusiast, with opposite views and having similar advantages for observation, could be induced to enlighten us with the results of his investigation, we might by comparison of notes be able to arrive at more decided conclusions on this really most important subject, especially in a country like this so liable to droughts. It is to be hoped that this discussion may discover such an observer. For my own part I have little to add likely to assist in such conclusions, except an attempt to account for the breaking out of springs alluded to by Mr. Abbott, and to suggest some reasons why forests should attract rainfall. There is no questioning his premise that the breaking out of springs in a country denuded of its forests by ring-barking is largely affected by its physical and geological features. From his description of the geological features of the range of country covered by his observation, it may safely be presumed that the springs are of deep-seated origin, whilst his account of the topography of the country shows that it offers a favourable position for the bursting out of such springs when relieved to a certain degree of atmospheric pressure. But the flow of such springs is at all times more or less affected by the condition of the atmosphere. For instance, the approach of heavy rains is often indicated hours before by their suddenly bursting out afresh, or by their larger increase in volume because of the decrease in the pressure of the atmosphere. Doubtless the breaking out of springs noted by Mr. Abbot, is due to just the same decrease of pressure, only from another cause. In the latter instance this decrease is produced by the effect of the solar rays on the exposed surface of the ground, which gradually heats the lower stratum of air, causing it to expand. This expansion lessens the atmospheric pressure and thus induces the flow of springs. Perhaps there is no part of the country where this favorable condition for constant flowing springs can be better exemplified than at the summit of the Great Divide in the vicinity of Mount Kosciusko. Here we find innumerable perennial springs jutting out in every direction on the treeless table lands and slopes, whilst in the forests, only a short distance below, not a sign of a spring hardly is to be seen in summer time. This conclusively proves that there is a greater pressure of atmosphere

over forests than over exposed surfaces, and this is chiefly due to the cooler temperature the forests by their shade induce. A forest therefore, though in a modified extent, occupies much the same position relative to pressure of air as the ocean. The temperature of the sea is always more equable than that of the land, owing to the envelope or interposition of innumerable particles of water that serve to make it cooler in summer and warmer in winter than the land, and this coolness by attracting the overflowing air which I have shown the solar heat has forced upwards from the earth by expansion produces a high pressure on the sea. The same cause produces a higher pressure of atmosphere on forests than on exposed surfaces, for a tree interposes a large shade between the sun and the earth, and therefore lowers the surface temperature by day and induces humidity by preventing the too rapid escape of moisture beneath it, and at the same time by its shade it protects the ground from evaporation. But the atmosphere just above a forest is constantly absorbing moisture therefrom, and therefore it is lighter than the current just above it again, so that it is constantly forced upwards. As these currents ascend they gradually become cooler, and should their aqueous vapour meet a stratum of air already laden to dew point, their additional moisture produces rain. Thus it appears to me that the very occurrence of springs, as noticed by Mr. Abbott after the destruction of the forests and where none apparently existed before, affords pretty conclusive evidence that a condition has been produced by ring-barking unfavourable to rainfall. Again, this lowering of the summer temperature and raising of the winter temperature by forests, is the very cause that induces constant change of currents productive of rainstorms, for it has been proved by the charting of winds with isobarometric lines, that the wind and consequently the rainfall depends on the pressure of the atmosphere, and therefore on its temperature and humidity. It has been shown, also, that winds chiefly blow from places where the pressure of air is high to places where it is low, and that variable winds are affected by local causes, such as the physical features of the country whether level or mountainous, the vicinity of sea or lakes, and lastly such as the prevalence of forest or desert country. We know, too, that given in any locality an excess or decrease of atmospheric pressure, temperature, or moisture, certain atmospheric changes inducing wind take place to restore the equilibrium thus disturbed, which again influences rainfall. Now forests, on account of the aqueous vapor rising from them and the greater pressure of air above them, offer conditions favourable to these atmospheric changes, and consequently favourable to the increase of rainfall. Thus it seems to me that forests must have a direct influence in inducing rainfall, for which reason they should be carefully cultivated. Whilst then I

would destroy all useless trees, I would suggest that especial attention should be given to the cultivation of thick shady deciduous trees in their place, such as the chestnut, walnut, plane, and sycamore trees on the plains and moderately elevated table lands of the interior, whilst the most valuable species of Californian pines and cedar should be cultivated on the coast range, in order to induce as much as possible that alternation of currents favorable to rainfall.

Mr. H. C. RUSSELL (Government Astronomer):—I should like to occupy the time of the Meeting for a few moments, to give expression to some of my own views upon this subject. It is one, as some of the members know, I have paid some attention to and have taken a great interest in, and it is not long since I endeavoured in the public prints to show that the result of investigations carried on in France, England, and America, in what seems to me the most conclusive way of testing the effect of forests on rainfall has been that no such effect can be discovered. Meteorological observations have been carried on in France for about 200 years, and no decrease in the rainfall can be discovered whatever, although the population of France has increased, and necessarily the amount of forests destroyed has been very great during that period. The same has taken place in England and in America. Now to my mind that is the strongest evidence of all. A great deal has been made of experiments carried on with the intention of showing that the temperature of the forest is very much lower than the surrounding area, and that the amount of rainfall deposited on the forest is much greater than that deposited on the plain country near it. But these experiments have continued only for a short time, and the evidence of different observers is so contradictory that it must be taken for what it is worth. It is a difficult thing to ascertain what is the amount of rainfall on a forest as compared with plain country near it. Then again we have statements published that forests are warmer than cleared country at night and cooler by day, and it has been asserted that because forests are cooler therefore more rain is deposited on them. I think those who say this must have overlooked the fact that if the forest is cooler, it is very little cooler, and is a very small body compared with the great extent of atmosphere above it; and everyone knows that if two masses of air of different temperature are brought together they soon take the mean temperature of the two, but the forest being but little cooler than the atmosphere and insignificant in extent relatively, it can have scarcely any effect in lowering the temperature of rain clouds. Again, Nature has provided us in New South Wales with a great stretch of plain country and alongside of it a great extent of forest. From a careful examination of the rain records on both, extending over several years, I cannot detect any difference in the proportion of

rainfall in the plain country and in the forest country, we are therefore in a position to say that our forests do not increase the rainfall. Again, it has been conclusively shown within the last few years that nearly the whole of the circulation of the atmosphere is a circulation in what is technically called the cyclone system. We all know what a cyclone is in the ordinary sense of the term, but it is only recently known that every wind is moving under the same laws as do those in intense and therefore dangerous cyclones: in fact, whenever we have a breeze or disturbance of the wind: that wind depends upon the relative heights of the barometer and on certain other circumstances. These ordinary cyclones are of enormous extent, and rain is found to be a necessary part of each cyclone. It is just as essential a feature of the cyclone as that the circulation of the wind is due to a fall of the atmospheric pressure, and further that the rainfall which we get from these storms is practically the whole of the rainfall that is deposited on the surface of the earth. Rains may occur in other ways, but the amount is relatively quite inappreciable, in fact, whenever it falls part of a cyclone system is passing over. These cyclones are from 1,000 to 3,000 miles in diameter, and such a system passes over the earth's surface just as a railway carriage passes over it, according to definite known laws at a definite rate, although the rate varies from 7 to 20 miles an hour, but still you find that the cyclone is travelling across the surface of the earth, and it is very little affected by the surface conditions. I do not see, therefore, how it is possible that the cutting away of a few trees over a mile or a hundred miles, can in any way affect the circulation of the atmosphere in these enormous cyclones which often cover six to eight millions of square miles. That to my mind is a very strong argument against the statement that cutting down forests will affect our rainfall. There is another point: with regard to the cutting away of forests, and their effect upon rainfall. We know from a paper Mr. Abbott read here some time ago that three-fourths of the forest land in the Upper Hunter has been destroyed by ring-barking, yet if you examine the records, the rainfall in that ring-barked country is just the same as on the surrounding country which is not ring-barked; and I think that is also a strong argument in favour of the view that forests do not affect rainfall. There is another circumstance not of so much importance, but still worth mentioning. Last year the rainfall in this Colony was heavier than it had been for any year before, since records have been kept. I ask those who argue that trees produce rainfall if it is possible that one year's rainfall should be so excessive compared with others because trees have been planted, and if the planting of trees last year or the year before produced the rainfall of 1887, what has produced the drought of 1888? Not the cutting down

of those trees certainly, because they have not been cut down. I should like to say also that, as far as I have been able to investigate the statements that forests produce or increase rain, generally no data are given i.e., the rain measures on cleared and uncleared forest are not given, in fact there is no scientific data to go upon. I would point out that not long since a gentleman holding a high position in a neighbouring colony made a statement, as reported by an officer in the Austrian service, that millions of trees had been planted in Victoria, and streams had burst out in more than one hundred places. That is the kind of statement usually made, and, upon enquiry, I found there was not a single instance in which there was any evidence that the planting of these trees had produced streams of water. These statements have been made for a long time till it has grown popular to believe them, and it is quite sufficient for the majority of persons to follow a popular belief.

Mr. MANN :—The result of my experience in this, tends to show that ring-barking forest trees materially encourages the growth of other vegetation. Large tracts of country which, previous to undergoing this process, were poor, barren wastes, almost destitute of water, are now well-grassed lands, and water in places rendered permanent or easily obtained. The amount of moisture drawn from the soil by a large tree, to be partly absorbed by the atmosphere by means of the leaves and branches, is something enormous. This is most noticeable in the Illawarra and Coast Districts, where the vegetation is semi-tropical, and extremely dense and succulent. Unfortunately ring-barking has generally been performed in a reckless manner, so that much valuable timber has unnecessarily been destroyed, while no shelter has been retained for the protection of stock. Regarding cyclones I have traced several for many miles by means of the fallen timber which occupied a strip of country of from one to two hundred yards wide. These cyclones are very destructive, and *twist* the heads off a tree rather than level it. Although the facts given by Mr. Russell show conclusively that forest country exerts no influence over the rain-fall, it is possible, that in crossing an open plain, a cyclone bearing rain-clouds might be diverted from its course by large patches of forest, and so cause a fall of ruin at those parts. I am under the impression that the erratic seasons we have had during the last few years will be shown to be the result of large islands or fields of ice, which have drifted within the climatic radius of this country. Not having a Gulf Stream to regulate the temperature, we are more susceptible to other influences.

Hon. G. H. Cox :—All those engaged in agricultural or pastoral pursuits in the country agree that this is a matter of

extreme importance. I have given this matter of ring-barking much attention, and have come to the conclusion just enunciated by Mr. Russell, that the forests can have little or no influence whatever upon the rainfall. I think people as a rule confound cause and effect. I know that on the eastern coast we have large forests and heavy rainfall. It is not the forests that cause the rainfall, but the heavy rainfall that causes the forests. I am also aware that the statements made by Mr. Mann can be borne out. I know of two instances in which ring-barking has caused springs to flow where they were not known before. I account for it in this way. When trees have been killed, the rain instead of falling only partially upon the earth falls wholly upon it, and falling upon the decayed leaves of these trees forms large reservoirs and breaks out into springs. Another curious matter. On the higher mountains, Mount Wilson for instance, when you denude the country of trees you make it very much drier. That is not the rainfall. It is the mists coming up from the sea. After a warm summer's day a cool wind springs up from the sea and brings up a mist. This mist is caught by the trees and vegetation, and hangs upon these and produces a large amount of fall. The ground is quite wet, and where there has been a denudation of trees the ground is quite dry. I am a believer in ring-barking; I do not believe it has any effect on the rainfall, but it tends rather to produce more moisture in the soil than was previously present.

Mr. HENSON:—While listening to Mr. Abbott's paper at the last Meeting, the thought occurred to me that the permanence of the flow of the water in the streams after the forests had been cut down, was largely due to the decay of the roots as mentioned by the last speaker. The ramifications of the roots of forest trees are very extensive, and after the trees have been cut down these roots decay, and form channels through which the water readily passes into the ground. The formation that surrounds us in the western suburbs is dense shale formation. The upper portion has been comminuted by rootlets. Many know the large forests that formerly grew in these districts. As those trees have been cut down, the water has penetrated along the rootlets and found its way into the ground. Of course the clay, which has been formed from the shale, retards the lateral travel of the water, but still the ground does absorb an immense amount of water after the trees have been cut away. Another thought occurs to me. A rain gauge placed at ground level I believe records a larger amount of rain than one at some height above the ground. Would a rain gauge in a forest amongst the trees record as much as on a plain adjoining? A portion of the rain must be intercepted by the foliage; the twigs and the trunk become thoroughly wetted, this

moisture does not fall to the ground and is removed by evaporation.

MR MANN :—On the Illawarra the decomposed leaves are never dry. There could never be a fair test.

MR. RUSSELL :—It is usual in taking observations to determine the rainfall in forests, to place one rain gauge on the ground in the open near the forest, and another in the forest in a place where the trees are cleared away, the reason, no doubt, why an elevated rain gauge catches less rain than one on the ground is that the velocity of the wind is greater as you rise from the surface of the ground, and the mouth of the gauge produces a little vortex motion of the wind which throws the rain out. The question has never been thoroughly investigated as to what effect, if any, forests have upon the rainfall, in fact it would require a great many years of observation before the question could be settled.

MR. W. M. HAMLET :—I quite agree with Mr. Russell, that we have no scientific data to enable us to determine the effect of the rainfall in connection with forests. It appears to me one thing has been lost sight of in connection with this discussion, and that is the natural function of the leaf of a tree, namely, that of evaporation ; and my own idea is that we may account for the occurrence of these springs after ring-barking in this way. Let us take the total area of all the leaves of a tree or a number of trees, and compare that with the area of the ground upon which the tree stands, the total area obviously will be considerably greater. Now, during a tree's life evaporation is going on, and water is being drawn up from the soil in order to produce the effect of growth in the tree. After ring-barking evaporation ceases, and there being no longer any outlet for the water from the soil, it must necessarily follow that the water which is already in the soil, and which has been accumulating in consequence of repeated rains, must find an outlet. That, I think, will account for the boggy nature of the soil after ring-barking under the conditions stated by Mr. Mann. Then, with regard to the remarks made by the gentleman who opened this discussion to-night. He said that there was a difference of atmospheric pressure on forest land—that there was a greater amount of pressure on forest land than on cleared land. I think that is utterly erroneous. I think if we took a barometer and stood it in a forest, and then took it to cleared land in the vicinity, there would be absolutely no difference whatever with regard to pressure, and that the diminution of pressure in any one place would not account for this previously dry place becoming covered with streams of water. I think the true explanation would lie in the question of evaporation.

Mr. GIPPS :—I said in the light stratum *just above* the forest, not *in* the forest.

Mr. ABBOTT, in reply, said :—I have not much to add to what I have written in my paper. I regret a little I did not quote more largely in the paper from a paper I read some seven or eight years back. I referred to the paper, but did not give the particulars there given. It is now about twenty years since ring-barking began on the piece of country I referred to in the paper. Then after ten years had elapsed, and the springs had remained permanent during that time, I made measurements of the water flowing in the creeks where it had been dry before, and those measurements gave a very large flow of water where there had been no water at all, proving that all the water thus measured was water that would not have been there at all except for some change, and the only change I knew was the ring-barking of the forests that had been destroyed. I waited then for eight years more, after some very severe droughts had occurred in this and other Colonies. I found these springs were not affected. They still continued to flow. I think that proves that Mr. Gipps' theory that the ring-barking alters the barometrical pressure over the country must be wrong, because a barometer does not remain permanently raised or lowered. If the springs were affected by the rise and fall of the barometer they would stop or flow. But they are not affected—the water has a regular flow. In the paper I read some seven or eight years ago for this Society, I referred to some observations by Professor Draper. He was the President of the Observatory at New York. Questions were put to him by I think the Legislature of New York for the purpose of settling whether the cutting down of the forests would cause a diminution in the water supply to the city of New York. Professor Draper, who was I believe a very eminent scientist in America (I suppose he was the most capable man they could find), examined into the matter with reference to the rainfall where records were kept in the Atlantic States of America, these records extending over nearly 100 years I think. He also took the records in Paris extending over nearly 200 years. The conclusion he communicated to those who put the question was, that the destruction of forests had not in any way affected the rainfall. He showed in his report that neither the temperature of the Atlantic States of America nor the rainfall had altered in any appreciable degree during the last century. I think that opinion is as good as any we are likely to get now. As to another matter raised in this discussion: the difference in the rainfall in forests and the open country. I have seen it stated that the temperature was lower in the forest, and therefore it must condense the moisture. It has always seemed to me that if the temperature is lower in the

forest, that lowering must be produced by evaporation, just as when we expose a water-bag to a dry atmosphere the water then becomes cool: below the temperature of the air—that is due to a physical law there is no escaping from. While evaporation goes on the temperature in the forest would be lower—as soon as the evaporation stopped the temperature would rise. Therefore I incline to the opinion that the temperature in a forest is not lower during rain—it is only lower in dry weather. I would also call attention to the matter Mr. Russell referred to, that nearly all these statements that the rainfall is increased by forest growth are merely theoretical. They are not the result of actual observation extending over a long period. But with reference to this piece of country I wrote about, I have my own personal observations extending over a period of 26 or 27 years, and the land has been in the possession of my family since 1848. All these creeks were dry up to 1869. From 1869 up to the present time (19 years) they have been running permanently; so that all these cases are matters of fact known to myself. We must be guided by fact in preference to theoretical ideas that forests condense the moisture. Another thing is, that this effect of deforestation of which I wrote is not confined to any small area of New South Wales. I find that in every part of this Colony from which I have been able to get information the same effect follows more or less. Another matter. In the thick forests on the coast range the dead leaves lying on the ground are never dry, but I do not think that proves anything at all, because in these rich brush lands the rainfall ranges from 120 inches. That is the reason why the ground is never dry—it is continually saturated with rain. There is no doubt that these forests on the coast range are produced by the rainfall, and not the rain by the forests. Allow me to refer to something that happened. When I wrote the paper for this Society in 1880, all the references made in that paper were to one particular area that had been ring-barked. At that time there were a number of creeks flowing eastward from a certain range. From that time up to now on the western side of that range the creeks all remained dry, while those in the eastern ring-barked side were running. Within the last two years I have ring-barked the western side, and new creeks are beginning to run permanently on that side. It follows almost immediately on the dying of the trees, generally within 18 months.

Rev. S. WILKINSON :—Two thoughts have occurred to me which at this stage of the proceedings may be just worthy of notice. Firstly, the ornamental point of view. For this object I have often been grieved to see that when forest land has been cleared, some portions have not been allowed to remain. Then there is the economic, I may say the humane point of view. In some

cold districts I have seen the cattle exposed during winter nights without any shelter whatever, causing also a considerable loss to those engaged in dairy pursuits. I think it is greatly to be regretted that any stock should unnecessarily be thus exposed to the inclemency of the weather.

Mr. ABBOTT:—I have not known of any permits being given of late years to ring-bark that did not stipulate for some timber being left growing for purposes of shade and ornament. The Local Boards, in whose hands the matter is, do not permit indiscriminate ring-barking.

Hon. G. H. Cox:—I move a vote of thanks to Mr. Abbott. I have read with pleasure the papers written by him.

Mr. RUSSELL:—I second the proposition. I think everyone, whatever may be his views upon the scientific question as to the effect of forests upon rainfall, will admit the national importance of preserving a certain quantity of trees, and planting forests where they are required. The misfortune is that questions of this nature get mixed up. But we are not discussing the question whether they are useful for commercial purposes. It is a scientific question that is being discussed now, viz. : whether trees produce or increase the rainfall. Whether trees do affect the rainfall or not I am sure every care will be taken by the Government of this Colony, as in other countries, to preserve a certain number of trees. But as I have said, that question is not being discussed to-night, but simply the scientific question.

The PRESIDENT then put the motion, which was carried unanimously.

ON THE INCREASING MAGNITUDE OF ETA ARGUS.

By H. C. RUSSELL, B.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

THIS remarkable star, which so surprised Sir John Herschel in 1837 by its sudden increase in magnitude, and which continued to increase until it was brighter than every star in the heavens, Sirius only excepted, has I think passed its minimum recently. It will be remembered that after reaching its maximum about 1843, it fell a little, but was still a bright 1st magnitude star until about 1856, when it began to fall rapidly, and by 1859 was only of the 3rd magnitude, and has ever since been going down in the scale of magnitude, until some have been led to think it would rise no more.

In 1871, when I carefully surveyed the whole cluster in which it stands, Eta was of the 7th magnitude, or adopting Gould's Standard of Star Magnitudes, which has been carefully prepared, my estimate of Eta was 6.8 magnitude. On 4th February, 1874, I was surprised to find it $\frac{1}{2}$ a magnitude smaller than in 1871, or 7.4 magnitude, and I have since been in the habit of frequently examining it and comparing it with several stars in its own cluster which are not variable. During the years 1875 to 1882 the change seemed to me inappreciable, but in 1883 the estimates varied from 7.5 to 7.8, in 1884 I made it 7.6, in 1885 and 1886 about the same, although in the latter year I several times thought it was getting brighter, in 1887 I was away, but the first examination on my return removed all doubt, there was evidently a very decided increase; adopting still Gould's Magnitudes for Stars of Comparison, I find Eta at the end of May, 1888, was of 6.9 magnitude, or almost as great as it was in 1871. These comparisons were made in the usual way, viz., by estimating in the telescope relative brightness of the star images.

But I have also compared it with six stars in its own cluster (the same stars used by the older method) by means of a wedge photometer, 180 measures have been made, and give the magnitude 7.24 as a result. I have also compared it in the same way with six stars in Kappa Crucis cluster, 90 measures have been made, which give the magnitude 7.42. My experience with the wedge photometer has been that red stars, of which Eta Argus is one, are made to appear smaller than they do by direct vision, or in other words, that red light is more absorbed by the wedge than white light, so that the magnitude of a red star by wedge photometer is smaller than it should be, and as appears in the foregoing, where direct comparison makes it 6.9, and the wedge 7.24. As all my previous comparisons were direct, and I think also those of other observers, we must take 6.9 as its present magnitude, and comparing this with the mean of my estimates for 1883 to 1886, or 7.64, it appears that Eta is now $\frac{3}{4}$ of a magnitude brighter than it was in 1883, and increasing rapidly, so that should the present rate of increase continue as we have every reason to believe it will, Eta will soon be visible to the unassisted eye again, which it has not been for 20 years.

In 1869 Prof. Loomis collected the then existing observations of Eta Argus, and came to the conclusion that its range was from the 1st to 6th magnitude, and its period 70 years, with minimum about 1870, but as you have just heard the minimum did not occur until about 1885, or 15 years after he supposed it would, and the magnitude got down to 7.64 instead of 6.

The previous minimum occurred long before there were any regular observers of the star's magnitude, and therefore we cannot

say definitely when it took place, but it seems probable that the period is about 80 years ; it is about 40 years since its maximum, and carrying this backwards, the observations since 1800 and the two previous ones in 1751 and 1677, will fit into places on the curve, 1751 by Lacaille at the Cape, 1677 by Halley at St. Helena.

It must, however, not be forgotten that this star when near its maximum was subject to remarkable fluctuations in brilliance, and it seems probable that it would present the same character at minimum, and such has been shewn by observation ; but the present increase in brilliance is so considerable, that I think there can be no doubt that the minimum is past, and that Eta Argus will again be a brilliant star in the heavens.

NOTES ON SOME MINERALS AND MINERAL
LOCALITIES IN THE NORTHERN DISTRICTS
OF NEW SOUTH WALES.

(With one Plate.)

By D. A. PORTER, Tamworth.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

IN a paper read before your Society on 5th Nov., 1884, I had the pleasure of offering a few observations on "Some Minerals and Mineral Localities in the Northern Districts of New South Wales," and I purpose in this paper to continue the same subject, as I think it is very desirable that every mineral locality in the Colony, so far as known, should be noted, so that they may be easily discovered by those who, in the future, may desire to submit them to further examination. The notes contained in this paper are the result of personal examination of the various minerals and localities referred to herein.

GOLD.

As gold is so widely distributed throughout the northern districts of this Colony, and as all the localities in which it occurs are well known and catalogued, I purpose only mentioning it in instances where something unusual is connected with its occurrence, such as its association in alluvial or matrix with other minerals or metals.

ALLUVIAL GOLD WITH METALLIC COPPER

Is found at the source of Wet Creek, near Mount Misery, Nundle. An assay of 100 grains of the sample gave—

Gold	...	...	...	...	23.0
Copper	...	...	...	...	61.0
Iron Oxides	...	...	...	...	10.0
Loss	...	...	...	...	6.0
					100.0

The iron oxides occur as magnetic and titaniferous iron. Professor Liversidge, who examined a sample forwarded by me in 1882, says, "The particles of metallic copper are much smaller than those of the gold, the latter, however, do not exceed a square millimetre in area. The gold is not much water-worn, and under the microscope is seen to be distinctly crystallized in parts. The grains of copper, although of more or less spherical form and with mammillated surfaces, are in some instances distinctly crystallized." Slates, jasperoid rocks, and serpentines occur in the vicinity, and are overlaid in part by basalt. No work has been done in this locality since it was first prospected in 1882, as the gold was found not to exist in payable quantities.

GOLD WITH SULPHIDE OF ANTIMONY AND ARSENIC.

Gold associated with stibnite and arsenic, or some arsenical compound, occurs in a large quartz-vein in the "Ellenora Gold Mining Company's" property at Hillgrove, about fifteen miles in an easterly direction from Armidale (N.E.*). Although when observed casually the particles of gold often appear to be attached to the stibnite, yet so far as my observation has gone, in no instance is this the case, close examination reveals the fact that each and every particle of gold although *almost* inclosed by the stibnite, is seated upon a larger or smaller particle of quartz. The arsenic is not observable in the stone or ore until heated in the kiln, when large quantities of the oxide condense in brilliant octahedral crystals in the cooler parts.

GOLD IN MISPICKEL.

At Bowling Alley Point, near Nundle, some fine specimens have been obtained from the "Carrington Reef." The gold bright and clean, and penetrating the mispickel in wiry forms in every direction.

GOLD IN CALCITE.

At Tea-tree Creek, about twelve miles S.E. from Barraba, in thin branching filiform masses. The calcite is white and opaque, and cleaves readily into rhombic fragments. Some specimens of pure white calcite, with the gold projecting from the cleavage

* N.E. is a contraction for the New England District.

planes of the mineral, are very handsome. Very beautiful specimens are obtained by dissolving the calcite, as the gold is then left in the most peculiar and fantastic forms. The auriferous calcite is found in veins traversing clay slates.

At Bingera, two miles S.E. from the town, in serpentine. A sample gave a return for gold at the rate of 9 dwts. per ton. The calcite in this locality differs from the auriferous calcite of Tea-tree Creek before mentioned, in being made up of thin plates, which are contorted and interlocked. The laminæ are, however, easily separated, and the surfaces are seen to be dull. These separated, thin plates are easily broken across in one direction, exhibiting small bright cleavage planes. The contained gold occurs in isolated particles, the largest of which would not be more than $\frac{1}{16}$ grain in weight. Small crystals of pyrite are also present in the calcite.

NATIVE ANTIMONY.

At Hillgrove Antimony Mines, fifteen miles easterly from Armidale (N.E.), in small isolated deposits in the vicinity of veins of stibnite. Amorphous, compact, colour and streak tin white. Hardness between 3 and 4, scratches calcite, Sp. G. 6, 69. Fracture irregular, rough; cleavage on small faces, imperfect. B.B. fuses easily, and becomes covered with prismatic crystals of oxide of antimony. Not of common occurrence. The country is principally of slate, more or less altered, and inclined from the horizontal at a high angle. On the northern side of the mines gneissic rocks are found outcropping. The principal mineral veins of the locality are found in the slates, and are composed of an amorphous quartz as the matrix. These quartz veins are in places accompanied by casings of a tough greyish rock, composed of whitish to colourless felspar, and dark green hornblende. At low levels in the ravines on the southern side of the principal mines this rock, which is probably a trachyte, is found as intrusive sheets, which appear in some measure to follow the bedding of the slates.

ANTIMONITE (Stibnite).

At the Hillgrove Mines before mentioned, associated with arsenic and gold, in quartz veins traversing slates. The best deposits of stibnite are generally found on the outer sides of the veins, near either the 'hanging' or 'foot' walls, but more or less of the ore is distributed through the quartz. Pyrite in small quantities is found in the stone, but no mispickel nor arsenical iron was observed, so that in what form the arsenic exists in the ore has not yet been ascertained. The antimony mines of this locality are now worked principally for the gold present in the quartz, as the low price of antimonial ore, at the present time, renders it of only secondary importance.

At Nundle, near the old flour mill in Oakenvale Creek, and extending thence in a northerly direction into Happy Valley. This lode has been prospected and deserted. The vein is small, and very irregular in width, from two to twelve inches, and the ore appears to be of inferior quality. This vein is in hard, jointed, argillaceous slates, which are much tilted.

On road Bendemeer to Walcha, seven miles from Bendemeer, in hard micaceous schists. The vein of ore appears to be about eight inches in thickness. No prospecting has been done in connection with this deposit beyond sinking two or three feet on the outcrop.

MOLYBDENITE.

At Wilson's Downfall, thirty miles north from Tenterfield, and one and a half miles westerly from Wilson's Downfall Post Office, in thin leafy forms in vein of milky quartz, traversing granitic rock; not common.

At Hogue's Creek, twelve miles north from Glen Innes (N.E.), near road to Tenterfield, in large quartz lode, associated with wolframite, chlorite, tin ore, and native bismuth. In thin brilliant plates, often inserted between crystals of quartz in geodes in the rock; not very abundant.

At Kingsgate Bismuth Mines, twenty miles east from Glen Innes (N.E.). Often accompanying wolframite and ores of bismuth, but in greatest quantity in large deposit of bluish-grey crystalline quartz, which, like that of the Hogue's Creek locality, has a coarsely granular appearance, and is easily broken or crushed. Crystals of molybdenite are not uncommon in this locality. They occur as low hexagonal prisms, rarely more than $\frac{1}{4}$ inch in length by $\frac{1}{2}$ to 1 inch across, rarely 2 or 3 inches broad. These prisms or plates are composed of very thin horizontal laminae, which are easily separated from each other. The laminae, often contracted in size, successively, from the lower ones upward; thus forming a bevelled edge, which in turn would ultimately form a hexagonal pyramid, were the process continued far enough. No such terminations to crystals were, however, observed. The molybdenite crystals are almost invariably depressed in the centres, as shewn in section (figure 13). Molybdenite in leafy and fan-like aggregations and deposits occurs in large quantities in this locality. Colour, lead-grey, brilliant metallic lustre on fresh cleavages. Soft, easily scratched by the finger nail; marks paper like graphite; opaque. Thin laminae, by transmitted light, blood-red. The deposits of molybdenite, bismuth, and other minerals, at Kingsgate, occur principally in pipe veins, and in irregular masses of quartz rock, in coarsely granular feldspathic granites.

ACTINOLITE.

At the Woolshed Gap, on road from Barraba to Bundarra, in radiated masses of slender prisms, in connection with a large vein of milky quartz in granite. The mineral is in places attached to the quartz, or penetrating it, but masses free from quartz occur, up to five or six pounds weight. Colour, brown or black, some with greenish tinge. Opaque in mass, but separate prisms translucent.

At Giant's Den Tin Mines, near Bendemeer (N.E.), on the highest peak of the Giant's Den Nob, in acicular crystallizations on cassiterite, and in radiated masses on opaque quartz; greenish-brown to brown, and nearly black.

Actinolite occurs in many places in the New England tin mining districts, in small veins, or in radiated isolated masses, more rarely in acicular crystals penetrating crystals of colourless or smoky quartz. Actinolite rock in water-worn pebbles and small boulders, is common in the alluvial tin workings two miles S.E. from Tingha (N.E.). These pebbles and boulders are very compact and tough, and often show a radiated internal structure when broken.

AXINITE.

At Bowling Alley Point, near Nundle, in granular masses and small crystals, with green epidote, in quartz vein, traversing hard splintery slates, on ridge about 150 or 200 yards south from the iron foot-bridge. Colour brownish, with pink tinge when newly broken; occurs only in small quantity.

BERYL.

At Glen Creek, near Emmaville (N.E.), two miles north from Dolcoath tin lode, *in situ* in small mineral vein, traversing indurated clay slates, associated in druses with crystals of topaz, quartz, and cassiterite; found also in isolated prisms embedded in the rock. Crystals transparent, rarely opaque, bright green to colourless. The largest crystals not more than $\frac{3}{4}$ inch in length by $\frac{1}{2}$ inch thick; generally striated longitudinally, but some with flat smooth sides, some crystals with terminations like figure 8, but mostly rough pointed like figure 9. The green colour is often distributed unequally in the prisms. The associated crystals of topaz are usually larger than those of the beryl, but are generally full of greyish-white cloudy matter or dark coloured inclusions, and abound in gas pores. Some of the smaller crystals are very brilliant, transparent and sound.

ZIRCON.

In the Inverell District zircons are found in many places over a large area, chiefly of basaltic country, forming the watershed of the Macintyre River on the northern side, and extending from N.

to E.S.E. from Inverell. They occur principally in the beds of streams, or scattered over low sloping ridges, and in the beds of clay and boulders, which form raised beaches along the creek sides, in many of the localities. The boulders in these old beaches are very much rounded and worn, and have been derived from the porphyrites of the surrounding country, which before the outpouring of the recent volcanic rocks, obtained as the principal rock formation of the localities referred to. The best zircon country is about Paradise Creek (County Gough), on many of the low ridges, and in the beds of the tributary watercourses between Upper Paradise Creek and the Swan Vale waters; in Swan Vale Creek and on the ridges on the northern side of same, extending from the Swan Vale Post Office to eight or ten miles westerly; at Apple Tree Gully, fifteen miles north-east from Inverell; at Swamp Oak Creek, and Frazer's Creek, on road from Inverell to Wellingrove; on road from Glen Innes to Inverell, two miles west from crossing of Waterloo Creek, in Macintyre's Lane. The zircons from these several localities mentioned, are usually more or less broken or cleaved, and very much worn and smoothed, but occasionally in fairly perfect crystals, of which figures 1 and 2 are representations. Some of the worn fragments, clear and colourless, have been observed of from four carats to eleven carats weight. The crystals are generally not much modified. All observed were prismatic, but rarely with double terminations. Colour, pale amber tint to colourless; transparent, rarely opaque, Sp. G. of six stones collectively = 4.547. The accompanying minerals seem to be of a similar kind in all the before-mentioned localities, consisting of smooth waterworn fragments of milky quartz, quartzites, pebbles of reddish-brown, yellow, buff, and black jaspers, and broken and worn fragments of pleonaste and sapphire. The pleonaste occurs rather plentifully, in pieces often $\frac{3}{4}$ inch in size, and occasionally in nearly perfect crystals. With the pleonaste, sapphire, and zircons, small rolled very highly polished pieces of black hornblende are sometimes found.

Zircons are met with at Elsmore, Stony Creek near Tingha, and at Red Hill, on Cope's Creek, above Tingha, as well as in several other places in the same district, as the principal constituent of a fine greyish sand, which is with difficulty separated from the finer of the stream tin ores. Under a magnifier the crystals are seen to be very perfect in form, long prisms with double terminations prevailing. Colour, pale yellowish, to grey, mostly transparent and of extremely brilliant lustre.

At Tilbaster, three miles north from Armidale, in creek bed, with gold and sapphires, generally in smooth almond shaped pieces, or broken fragments, often five or six carats weight; larger pieces

rare. Colour, garnet red, transparent. Formation, granite, basalt, slates and conglomerates.

At Lyndhurst, thirty miles north-east from Armidale, in creek near Lyndhurst homestead, in pieces more or less rolled, and up to half-ounce in weight. Generally translucent, or opaque, small pieces transparent, colour pale sherry-red to brownish-red. Hard splintery argillaceous slates prevail in this locality.

At Rocky River gold-field, near Uralla (N.E.), in auriferous drifts, with titanite iron, topaz, and sapphire, the latter only in small fragments and rare. Colour, wine red, pale red, greyish, rarely green, some small crystals ruby red; transparent to opaque. Sp. G. 4.55 to 4.56. The zircons in this locality occur as octahedrons, formed by the association of the terminal tetragonal pyramids. The prismatic form, if at all existing, must be extremely rare, as not one example was observed in the examination of some thousands of specimens. Crystals more or less fractured, but not appreciably worn; the smaller crystals, as usual, being the most perfect. Large pieces occasionally, but not of common occurrence; three of the largest pieces noticed weighed 45, 39, and 15 carats. Sp. G. 4.55 to 4.64. Colour, garnet red; transparent, but slightly flawed.

At Oban (N.E.), in the Ann River, in waterworn pieces, with red spinel, sapphire, topaz, cassiterite, gold, and titaniferous iron; rare. Colour, pale yellowish red. A stone from this locality weighed 48 carats, but contained flaws and blemishes. Sp. G., 4.64.

In the Mann River and Bald Nob Creek, near Glen Innes, with stream tin ore and corundum. Nearly colourless to pale reddish. The paler coloured stones often with patches of deeper colour in part; very much waterworn, transparent, translucent, rarely opaque; common in pieces 5 to 8 carats.

At Nundle gold-field, in the auriferous cemented gravels of Mount Pleasant, and less plentifully in several other parts of the field. At Mount Pleasant the associated minerals are chromite (in small black shining octahedrons), magnetite and other oxides of iron; small quantities of titaniferous iron sand are usually present. The zircons do not occur in any very considerable quantity, an ounce or two, only, being contained among the concentrates from a month's ground sluicing. They are generally much worn and with smooth polished surfaces. Occasionally perfect crystals are met with, which almost invariably have very short prisms and modified terminations, the normal planes and faces being often nearly extinguished by the replacement of edges and solid angles. Simple forms rare; crystals and fragments small; rarely more than $\frac{1}{16}$ inch in area. Colour, pale amber

yellow to sherry red, transparent, opaque. Fig. 14 is of a crystal from this locality, it is however exceptional with reference to development of prism.

SPINEL.

At Oban (N.E.), in the Ann River and above its junction with the Mitchell River, also in the Mitchell River, in rounded pieces with rough surfaces, appears as if little waterworn, but without trace of crystalline form. Colour, dark wine-red, transparent; observed up to $15\frac{1}{2}$ carats in one specimen, average for six others 6.6 carats each. The spinels from the Ann River are generally free from flaws and imperfections. Sp. G. 3.69, hardness over 8 scratches topaz readily. Found with gold, tin ore, titanite iron, topaz, zircon, and sapphire. Fragments of spinel are found with gold and other minerals at Bingera, Rocky River, and Nundle goldfields, but are generally small or opaque. A piece from Uralla weighed considerably over 1,000 grains, had a Sp. G. of 3.81, was rose-red, but dull and opaque, and very much waterworn.

GAHNITE.

About half-a-mile west from Great Northern Railway, at a point about two and a half miles north from Bolivia Railway Station. Occurs as a lode or vein ten to twelve inches wide, in granite. Massive, crystalline. Some very small cavities exist in the mass, in which the mineral has crystallized out in minute octahedral forms. Colour of massive mineral, dull bluish-grey, opaque; crystals greyish, with violet tinge, and transparent. Contains an admixture of feldspar. Sp. G. 3.56.

PLEONASTE.

Pleonaste occurs more or less plentifully with zircons and sapphires, at Apple Tree Gully, near Inverell. At Swamp Oak Creek, in the Inverell District, and about Paradise Creek (County Gough). At the zircon locality, on road from Glen Innes to Inverell, and among the pebbles in the beds of the Clairvaux and Furracabad Creeks, near Glen Innes. Also on south side of, and one quarter of a mile from the crossing of the Severn River, on road from Emmaville to Inverell. Generally occurs in broken fragments, irregularly shaped, rough, or waterworn and smooth; pieces 60 to 70 grains, common. Occasionally in tolerably perfect crystals. Black, opaque, exterior dull, but newly broken surfaces very lustrous. Fracture conchoidal, tough. Sp. G. 3.91, hardness over 8, scratches topaz.

VESUVIANITE (Idocrase).

Near crossing, and on eastern side of Ironbarks Creek, on New Road from Barraba to Bundarra (N.E.), in minute yellowish crystals, lining cavities in massive garnet. Crystals, transparent

to translucent; too small to admit of Sp. G. being taken, but aggregates from druses gave Sp. G. 3.19. Brittle, easily fusible to a blebby glass. The crystals have more complicated terminations than those from Bowling Alley Point* (see figure 12). The massive garnet referred to constitutes a large vein in the serpentine rocks of the locality.

RHODOCHROSITE (Mn Fe CO_3).

At Webb's Lode Silver Mine, near Emmaville (N.E.), in leafy and granular aggregations, at times two inches in area; also in small globular forms, seldom larger than an ordinary pin-head. In veins and small drusy cavities in the lode stuff; associated with and often seated upon crystals of quartz, and more rarely on crystals of galena, blende, tetrahedrite, lollingite, mispickel or fluorspar. Colour, pale nankin-yellow to brownish-yellow. Hardness about 3. Effervesces with HCl., and reacts for iron and manganese. Not very plentiful. The mineral veins of this locality are in hard splintery jointed argillaceous slates, which are in some places very much altered.

SIDERITE.

At Big Plain, on road from Inverell to Warialda, lining cavities in basalt, from the Government Well. In rhombic crystals with curved faces; crystals small, not more than $\frac{1}{8}$ inch square. Colour, yellowish-brown, reddish-brown, grey; opaque, but thin splinters transparent. BB. decrepitates, does not fuse, but becomes black and strongly magnetic. In fine powder effervesces with warm HCl. With borax and microcosmic salt dissolves slowly, giving an iron reaction only; with soda on platinum foil, trace of manganese. A globular form of this mineral (Sphaerosiderite) is present with the crystalline variety, and occurs in masses half-an-inch across; some of the spheroids have a radiated structure, but are often composed of concentric coatings. Sphaerosiderite also occurs in basalt in the Emmaville District. BB. and with reagents, behaves same as siderite.

CALCITE.

- Deposits of calcite are common in the limestone formations, which extend with few breaks, from the Isis River, thirty miles south of Nundle gold-field, to Bingera, sixty miles in a northerly direction from Tamworth. Often in concentric aggregations or in stalactitic forms, also compact and cleavable. Colour, reddish, brownish, grey, nearly white. Translucent to opaque; not transparent.

* See Proceedings Royal Society, N.S.W., 1884, Vol. xviii.

At Tamba Springs, Liverpool Plains District, in veins and deposits in basaltic rocks. Massive, cleavable, no crystals observed. Brownish, yellowish, to colourless. The latter variety (Iceland spar) often in pieces two or three inches in diameter.

At Dangar's Gully, Nundle, in rhombic crystals in cavities in nodules of magnesian rock. The crystals often arranged in groups of three, and then presenting the form of a nail-head; also in rosette forms, from the grouping of several individuals. Colour, pale green to greyish. Translucent, gives strong iron reaction with reagents.

At Ben Lomond (N.E.), crystallized in cavities in basalt, with zeolites. Reddish, yellowish, colourless; mostly transparent, some opaque. Figures 3, 4, 5 are forms of crystals from this locality.

ARAGONITE.

Three miles north-east from the Big Plain Hotel, on road from Inverell to Warialda, in nodules in basaltic rocks. The nodular masses have a radiated structure, and are at times as much as twelve inches in diameter, generally whitish and translucent or opaque, but some transparent, with a pinkish tinge.

At Swan Vale, on road from Glen Innes to Inverell, one mile north from Swan Vale Post Office, in basaltic rocks, often in nodules, three inches in diameter, some radiated, but most compact and tough. Colour, greyish to nearly white; translucent.

Aragonite occurs in radiated transparent yellowish masses in several localities on the Myall Creek Estate, near Bingera.

NATROLITE (Mesotype).

At Ben Lomond (N.E.), with crystals of calcite, chabazite, and analcite, in radiated or incrusting tufts of delicate acicular crystals, in cavities in vesicular basalt. Colour, snow-white in mass, but individual crystals are really colourless.

At the Caves, five miles S.E. from the Swan Vale Post Office before mentioned, in rocks similar to those of the Ben Lomond localities; very plentiful, in acicular crystals, radiated and incrusting, transparent; aggregates appear snow-white.

Two miles west from Elsmore, on bank of the Macintyre River, near Inverell Road, in basalt. Compact, radiated, white, opaque.

HEULANDITE.

At Werriis Creek, Great Northern Railway, near station house, crystallized in cavities in trappean or basaltic rocks; associated with stilbite. Crystals small, not more than $\frac{1}{8}$ inch in length; rare. Colour, pale yellowish white, transparent.

CHABAZITE.

At Ben Lomond (N.E.), in rhombic crystals (like figure 6) in cavities in amygdaloidal basalt, with other zeolites and calcite. Colourless and transparent when moist, usually white and opaque when dry. Occurs with other zeolites in the basalts about Emmaville. Phacolite is found in isolated crystals, in basalt, near the bridge at Inverell; translucent, friable (in forms like figure 7).

ANALCITE.

At Ben Lomond (N.E.), in trapezohedra grouped together in druses, or lining the walls of cavities in basalt. Crystals generally very perfect. Colourless, sometimes massive and opaque. Occurs also in the vesicular basalts of the Emmaville District.

LAUMONTITE.

Fifteen miles from Tamworth, in Old Goonoo Goonoo Creek, a quarter-of-a-mile above crossing of the road to Thos. Blevin's farm, in vein in fossiliferous rocks. The vein is about two inches in width. Colour, creamy tinted, opaque, pulverulent, very few crystals. Also two miles from James Swain's farm, seven miles S.E. from Carroll (Liverpool Plains), in veins in calcareous slates with stilbite and calcite; creamy white, opaque, good crystals though small.

At Werris Creek, crystallized; in small veins with stilbite in trap rocks (forms like figure 11). Crystals not common, usually amorphous.

STILBITE.

At Werris Creek in nodular deposits, and in crystals in amygdaloid, also in veins, associated with, and often enclosing, white opaque calcite. Crystals like figure 10 but small, not more than $\frac{1}{8}$ inch in length. The nodules exhibit a very perfect cleavage, and a pearly lustre. Colour, pale flesh red, to yellowish white, and nearly colourless. Transparent in thin laminæ. Some of the uncrystallized mineral may be heulandite.

Near James Swain's selection, seven miles S.E. from Carroll (Liverpool Plains), in veins, near rocks containing marine fossils. Often inclosing nodular masses of white calcite. Crystals small.

At Walcha Road, Great Northern Railway, near railway station, in veins in decomposing granite. Crystals radiately compacted, but often with free terminations. Colour, pale buff, greyish, or nearly white translucent or opaque, pearly lustre, friable; common.

ON A SIMPLE PLAN OF EASING RAILWAY CURVES.

(One Plate.)

BY WALTER SHELLSHEAR, Assoc. M. Inst., C.E.

[*Read before the Royal Society of N.S.W., June 6, 1888.*]

ALTHOUGH universally admitted that it is a desirable thing to ease off the junction of the straight and curved portion of railways, also to ease off the junction of two reversed curves by a gradual increase of curvature, yet hitherto, with few exceptions, little has been done by English engineers when setting out railways, in the way of putting this into practice.

The object of this paper is to bring under attention a simple plan by which this can be done, without adding materially to the work of the surveyor, or overtaxing his brains with obtuse formula.

Of all curves the circle is most easily set out in the field, and for this reason, no doubt, the more complicated elastic curves have with few exceptions been carefully avoided. The circle being the easiest curve to set out, it will no doubt continue to be the one generally used, and if supplemented by a short curve of adjustment where it joins the straight line, the circle leaves little to be desired in the way of suitability.

Froude's method of easing curves, as published in Rankine's "Civil Engineering," although sound in principle, is somewhat tedious in application.

The problem that is required to be solved, is to find a curve which deviates from the point of zero curvature by a perfectly gradual increase curvature, and to see how such a curve can be applied to ordinary circular curves.

The cubic parabola is a curve which meets our requirements, as it deviates from the point of zero curvature by a perfectly gradual increase of curvature, and for a small portion of the curve the curvature is small, and is proportional to the distance from the point of zero curvature.

Now as the curvature in the cubic parabola deviates from the point of zero curvature by a perfectly gradual increase of curvature, it follows that at some point in the curve its radius of curvature is equal to the radius of a circle of any particular radius, and that it can therefore be so located that it will make a perfectly gradual curve of transition from the straight line to the circle.

The problem that has to be solved, is to so locate the circle and the cubic parabola, that at the point where they have an equal radius of curvature, they may have a common tangent.

THEORETICAL INVESTIGATION.

For the following investigation of the properties of the cubic parabola, as applied to transition curves, the author is indebted to Professor James Thompson, of the Glasgow University.

Definition :—The cubic parabola is a plain curve, which deviates from the point of zero curvature by a perfectly gradual increase of curvature, and for a small portion of the curve the curvature is small, and is approximately proportional to the distance from the point of zero curvature.

The equation of the cubic parabola is $y = mx^3$ where m is a constant numeric, where the axis of x is tangential at the point of inflection.

Fig. 1.

Definition :—The rise per unit of length = steepness.

To find the steepness of a curve at any point :—Let O be the point of inflection, and YY the axis of Y , and XX the axis of X .

Fig. 2.

$$\begin{aligned} AB &= dx \\ BP_1 - AP_1 &= dy \\ (y_1 + dy) &= y_1 \end{aligned}$$

To express the steepness of the curve at any point it is expressed as the tangent of the inclination at that point.

Let θ = angle of inclination to OX at P_1 , then $\tan \theta$ = steepness of the curve at P_1 , but steepness at the point P_1 , = $\frac{dy}{dx}$
 $\therefore \frac{dy}{dx} = \tan \theta$ where $\frac{dy}{dx}$ is very small.

Fig. 3.

Let AE be a unit of length, and let the angle DAE be θ , then $DE = \tan \theta$.

Let AB be very small and be represented by dx , and let BC be very small and be represented by dy .

$$\text{Then } \frac{BC}{AB} = \tan \theta = \frac{dy}{dx}$$

In the cubic parabola we have :—

$$y = mx^3, \text{ (in general).}$$

$$y_1 = mx_1^3, \text{ when } y_1, \text{ and } x_1, \text{ are particular values of } y \text{ and } x,$$

Also $y_2 = mx_2^2$ when x_2 and y_2 are particular values of x and y .

If $y_2 - y_1 = dy$, and $x_2 - x_1 = dx$

Then $y_2 = m(x_1 + dx)^2$.

$$\therefore y_2 = m \{x_1^2 + 3x_1^2 dx + 3x_1(dx)^2 + (dx)^3\} = mx_1^2 + 3mx_1^2 dx + 3mx_1(dx)^2 + m(dx)^3$$

But $y_1 = mx_1^2$, and $dy = y_2 - y_1$,

$$\therefore dy = 3mx_1^2 dx + 3mx_1(dx)^2 + m(dx)^3$$

$$\therefore \frac{dy}{dx} = 3mx_1^2 + 3mx_1 dx + m(dx)^2.$$

When $\frac{dy}{dx}$ are very small they become equal to $3mx_1^2$, but

$$\tan \theta = \frac{dy}{dx} = 3mx_1^2.$$

The tangents of small angles are (approximately equal) \doteq to the angles in radian (circular) measure. $\therefore \theta \doteq 3mx_1^2$.

Fig. 4.

$$\frac{dy}{dx} = 3mx_1^2$$

$$\tan \theta = 3mx_1^2$$

$$\theta \doteq 3mx_1^2 \text{ (when } \theta \text{ is small).}$$

Let ds = a small increase of length on curve, for length dx on ordinate.

When the angle is small we may use ds , or dx , at discretion, for they are \doteq to each other.

Let the curvature at P_1P_2 be denoted by γ (gamma).

$$\text{Curvature} = \gamma = \text{change of angle of inclination} = \frac{d\theta}{dx} \doteq \frac{d\theta}{ds}$$

Required the value of $\frac{d\theta}{dx}$ which will give the curvature γ .

$$\theta_1 = 3mx_1^2$$

$$\theta_2 = 3mx_2^2$$

$$\theta_2 = 3m(x_1 + dx)^2,$$

$$\theta_2 = 3m \{x_1^2 + 2x_1 dx + (dx)^2\}$$

$$\theta_2 = 3mx_1^2 + 6mx_1 dx + 3m(dx)^2$$

$$(\theta_2 - \theta_1 = d\theta) \therefore d\theta = 6mx_1 dx + 3m(dx)^2$$

$$\therefore \frac{d\theta}{dx} = 6mx_1 + 3m dx$$

But when dx is very small, $3 m dx$ vanishes and $\frac{d\theta}{dx} = 6 mx_1$ for curvature at x_1 .

$$\text{In general } \frac{d\theta}{dx} = 6 mx$$

But $\frac{d\theta}{dx}$ is equal to curvature = γ .

$$\therefore \gamma = 6 mx.$$

To apply the cubic parabola to easing the transition of circular curves.

$$y = mx^3$$

$$\gamma = 6 mx$$

$$R = \frac{1}{6 mx}$$

$$\frac{dy}{dx} = \tan \theta = 3 mx^2 = \text{steepness at the point } x.$$

To adjust the circle to the curve.

Fig. 5.

Let R = radius of curvature of circle.

X and Y particular values of x and y .

Let P be the point of contact.

$\left. \begin{matrix} TP = Y \\ OT = X \end{matrix} \right\}$ = values of x and y at point of contact P .

$$\text{Radius of curvature at } P = R = \frac{1}{6 mX}$$

X = length of curve of adjustment.

$$6 mX = \frac{1}{R} \quad m \text{ is a constant.}$$

$$\therefore m = \frac{1}{6 XR}$$

\therefore the curvature is determined.

Proposition:—To find the value of $(Y = TP)$ in terms of $(X = OT)$ and also in terms of R .

$$Y = mX^3.$$

$$m = \frac{1}{6 XR}$$

$$\therefore Y = \frac{X^3}{6 XR}$$

$$\therefore Y = \frac{X^2}{6 R}$$

$$\therefore Y = \frac{4}{6} \left(\frac{X}{2} \right)^2 \frac{1}{R}$$

Let the tangent offset be represented by $\tau = UP$.

$$\tau \times (2R - \tau) = \left(\frac{X}{2}\right)^2 \text{ (Euclid, Book iii., Prop. 35)}$$

When τ is very small. $\tau \times (2R - \tau) \doteq \tau \times 2R$

$$\therefore \tau \times 2R \doteq \left(\frac{X}{2}\right)^2$$

$$\text{Or } \tau \doteq \frac{\left(\frac{X}{2}\right)^2}{2R}$$

$$\tau \doteq \frac{3}{6} \left(\frac{X}{2}\right)^2 \times \frac{1}{R}$$

$$\doteq \frac{3 \left(\frac{X}{2}\right)^2}{6R}$$

$$\text{But } Y = 4 \frac{\left(\frac{X}{2}\right)^2}{6R}$$

$$\therefore Y = \frac{4}{3} \tau \text{ where } \tau \text{ is small.}$$

Proposition :—To find the position of the circle.

$$\frac{dy}{dx} = 3mx^2$$

$$\frac{dy}{dx} = 3mX^2. \text{ (at } P\text{)}$$

$$\text{But } m = \frac{1}{6RX}$$

$$\therefore \frac{dy}{dx} \text{ at } P = \frac{3X^2}{6RX} = \frac{3X}{6R} = \frac{X}{2R}$$

$$\frac{PL}{LC} = \frac{dy}{dx} \text{ or } \frac{PL}{R} \doteq \frac{dy}{dx} \text{ or } \frac{PL}{R} = \frac{X}{2R}$$

$$\therefore PL = \frac{X}{2}$$

$$OQ = TP$$

To show that $MN = \frac{1}{4} TP = \frac{1}{4} Y = h$

Let x_1 and y_1 be co-ordinates for points in circle for origin O ;
and let $MN = h$

$$\text{But } y_1 \doteq h + \frac{\left(x_1 - \frac{X}{2}\right)^2}{2R}$$

$$Y = h + \frac{\left(\frac{1}{2}X\right)^2}{2R} \text{ but } X^2 = 6RY$$

∴ To get h in terms of Y by eliminating X

$$\begin{aligned}\text{We get } Y &= h + \frac{6RY}{4} \times \frac{1}{2R} \\ &= h + \frac{3}{4}Y\end{aligned}$$

$$\therefore h = \frac{1}{4}Y \text{ but } h = MN \therefore Y = 4MN$$

Therefore the distance between the real auxiliary tangent
 $= h = \frac{1}{4}Y$.

PRACTICAL APPLICATION OF THE CUBIC PARABOLA FOR EASING RAILWAY CURVES.

From the above investigation we have got the following results :—

That from the origin of the curve to a vertical line drawn through the centre of the circle, is half the length of the curve of adjustment. Also that the distance the circle has to be set in from the parallel tangent, is equal to one-third of the tangent offset at the point of junction of the circle and the cubic parabola, and is also equal to one-fourth of the ordinate at the same point.

Perhaps the best way of illustrating the matter, is to give one or two practical examples.

Example I.

It is desired to ease a curve of 10 chains radius, through a length of 2 chains.

The first point to be determined is at what parallel distance from the straight line will the tangent to the circle be.

We have $X = 2$ chains

$R = 10$ chains

$$m = \frac{1}{6XR}$$

$$\therefore m = \frac{1}{6 \times 2 \times 10}$$

$$= \frac{1}{120}$$

Again we have $y = mx^3$

$$= \frac{1}{120} \times 8$$

$$= \frac{2}{30}$$

And $h = \frac{1}{4}Y$

$$\therefore h = \frac{1}{60}$$

Therefore the distance of the straight line from the tangent to the circle is $\frac{1}{8}$ of a chain, or 1.1 feet, or 13.2 inches, and the offset at $Y = 4.4$ feet, or 52.8 inches.

The other points in the curve have ordinates proportional to the cube of the distance from the origin, and to facilitate the calculation of these offsets a table will be found in the Appendix, where these proportions have been calculated out; also a table giving offsets for all curves from 5 to 20 chains radius eased through a length of 2 chains.

Example II.

It is desired to ease a curve of 4 chains radius through a length of 1 chain.

To find the distance of the tangent to the circle from the straight line

We have $X = 1$ chain

$R = 4$ chains

$$\begin{aligned} m &= \frac{1}{6XR} \\ &= \frac{1}{6 \times 1 \times 4} \\ &= \frac{1}{24} \end{aligned}$$

Again we have $y = mx^3$

$$\begin{aligned} &= \frac{1}{24} \times 1^3 \\ &= \frac{1}{24} \end{aligned}$$

$$h = \frac{1}{4} Y = \frac{1}{24} \times \frac{1}{4} = \frac{1}{96}$$

Therefore the distance of the straight line from the tangent to the circle is $\frac{1}{96}$ of a chain, or .68 of a foot, or 8.16 inches, and the offset at $Y = 2.72$ feet, or 32.64 inches. Other points in the curve can be calculated by the attached table of proportions.

In conclusion, although there may not be much that is original in this paper, the author is not aware that any tables giving the practical application of this system have ever been published before, and he hopes that they may be found useful to the railway engineer.

APPENDIX.

Table giving proportion of offsets for curve of transition, when 0 is the origin of the curve, and the offset at the point of contact = 1.

FOR 16 POINTS ON THE CURVE.

Origin.								Centre.									P't. of Contact.
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0	·00024	·00195	·00659	·01562	·03051	·05273	·08374	·125	·17797	·24414	·32495	·42187	·53637	·66992	·82397	1·0	

FOR 8 POINTS ON THE CURVE.

Origin.				Centre.				Point of Contact.
0	1	2	3	4	5	6	7	8
0	·00195	·01562	·05273	·125	·24414	·42187	·66992	1·0

FOR 4 POINTS ON THE CURVE.

Origin.		Centre.		Point of Contact.
0	1	2	3	4
0	·01562	·125	·42187	1·0

Table of offsets and distances of parallel tangents for curves from 5 to 20 chains radius, eased through a length of 2 chains, giving 8 offsets for each curve.

R. Radius of Curve.	h. Distance of Parallel Tangent.	Origin.	Centre of Curve = $\frac{h}{2}$								Point of Contact = Y.	Tangent Offset = τ .
			1	2	3	4	5	6	7	8		
Chains.	In.		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
5	26.6	0	.2	1.6	5.5	13.3	25.7	44.6	70.6	105.4	79.2	
6	22.0	0	.17	1.4	4.6	11.0	21.5	37.1	58.9	88.0	66.0	
7	18.8	0	.15	1.18	4.0	9.4	18.4	31.8	50.5	75.4	56.5	
8	16.5	0	.13	1.03	3.5	8.2	16.1	27.8	44.2	66.0	49.5	
9	14.6	0	.11	.91	3.1	7.3	14.3	24.7	39.2	58.5	43.9	
10	13.3	0	.10	.82	2.8	6.6	12.9	22.3	35.4	52.8	39.6	
11	12.0	0	.09	.75	2.5	6.0	11.7	20.2	32.2	48.0	35.9	
12	11.0	0	.08	.69	2.3	5.5	10.7	18.6	29.5	44.0	33.0	
13	10.1	0	.08	.63	2.1	5.0	9.9	17.1	27.2	40.6	30.5	
14	9.4	0	.07	.59	2.0	4.7	9.2	15.9	25.2	37.7	28.3	
15	8.8	0	.07	.55	1.8	4.4	8.6	14.8	23.6	35.2	26.4	
16	8.2	0	.06	.51	1.7	4.1	8.0	13.9	22.0	32.9	24.7	
17	7.7	0	.06	.48	1.6	3.8	7.6	13.1	20.8	31.0	23.3	
18	7.3	0	.06	.46	1.5	3.6	7.1	12.4	19.6	29.3	22.0	
19	6.9	0	.05	.43	1.5	3.4	6.8	11.7	18.6	27.7	20.8	
20	6.6	0	.05	.41	1.4	3.3	6.4	11.1	17.7	26.4	19.8	

$$Y = mX^3. \quad m = \frac{1}{6} \frac{1}{X R^2}. \quad h = \frac{1}{4} Y = \frac{1}{3} \tau. \quad Y = \frac{4}{3} \tau.$$

τ = Tangent offset.

$X = 2$ chains in above table.

WEDNESDAY, 6th JUNE, 1888.

Sir ALFRED ROBERTS, President, in the Chair.

Twenty-five members were present.

The minutes of the last meeting were read and confirmed.

The certificates of two candidates were read for the third time, of three for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Blaxland, Walter, F.R.C.S., *Eng.*, &c., Sydney.

Clubbe, C. P. B., L.R.C.P., *London*, M.R.C.S., *Eng.*, Randwick.

The Chairman announced that the Council had awarded the Society's Medal and money prize of £25 to the Rev. J. E. Tenison-Woods, F.L.S., F.G.S., for his paper upon "The Anatomy and Life-history of Mollusca peculiar to Australia."

He also stated that Mr. Robert Etheridge, Government Palæontologist, being now a resident of Sydney, had retired from his Corresponding Membership, and become an Ordinary Member of the Society.

The following letters were read from the Rev. J. E. Tenison-Woods, F.L.S., &c., acknowledging the award of the Society's Medal and money prize; and from Hyde Clarke, Esq., London, a Corresponding Member of the Society :—

533 Elizabeth Street, Sydney,
31st May, 1888.

F. B. Kyngdon, Esq., Hon. Sec. Royal Society of N.S.W.

Sir,—I have the honor to acknowledge receipt of your letter conveying to me the agreeable intelligence that the Council of the Society had awarded to me the prize and the Society's Medal for my essay on "The Anatomy and Life-history of Mollusca peculiar to Australia." I have also to acknowledge a cheque for £25, being the amount of the Society's prize.

Will you kindly convey to the Council my sincere thanks for the honor thus done me, and assure them that the Medal will be treasured by me and the award considered distinguished encouragement to research in biology.

I beg to enclose you a cheque for the sum of five pounds (£5) as a contribution to the building fund of the Society, which the Council will do me a favor by accepting.

I will revise the manuscript as soon as possible, and will, with the permission of the Council, add some interesting observations which I have been able to make since the essay was first sent in. I will return it ready for the press in a few days.

I have the honor to be, Sir,

Yours very faithfully,

J. E. TENISON-WOODS.

32 St. George's Square, S.W.,

London, 18th April, 1888.

Dear Sir,—I have received the 20th Volume of the *Journal of the Royal Society*, and Part ii. of Vol. xxi. These I beg to acknowledge with sincere thanks.

I note with interest the paper of Rev. G. Pratt on the "Comparison of Dialects of E. & W. Polynesia and Australia, &c." All such matter tends to illustrate an obscure subject. I may, however, repeat that the analogies of Australian as they belong to the general body of language, so must they be more widely illustrated, as I shewed in my paper before the Royal Society.

As this is the year of your Jubilee, I beg to congratulate the Society, and to regret I can take no active part in its celebration.

To most the hundred years must seem a very remote epoch. To me it is not, for in my early years the generation which had known Cook's discoveries and taken part in the establishment of New South Wales still remained. To me its traditions are fresh, and in nearly seventy years I have watched with interest the later and wonderful growth of your communities.

There are some of us still alive who saw Cook's ship lying in the Thames, and his men in Greenwich Hospital. It is therefore a matter to me of intense gratification to see taking a great place in the regions of civilization, a great Continent—which I saw figuring in the maps as *Terra Australis Incognita*—lost to the world for so many ages.

Not least among marvellous events is the opening to us and to you of the new route across the Pacific Ocean to Vancouver. Noolka, as it was then called, was to me no unfamiliar name. Some of our Australian friends have been born to the full birthright of all such glories, but to myself and those who remember their dim and doubtful beginnings, and the arduous labour of the pioneers by whom success has been achieved, the history of Australian progress has been among the wonders of our age.

Yours faithfully,

HYDE CLARKE,
Corr. Member Royal Society of N.S.W.

To Prof. A. Liversidge, M.A., F.R.S.,

Hon. Secretary Royal Society of N.S.W.

The following papers were read :—

1. "Notes on some Minerals and Mineral Localities in the Northern Districts of New South Wales," by Mr. D. A. Porter, Tamworth.

2. "Forest Destruction in New South Wales, and its effect on the flow of water in water-courses and on the rainfall," by Mr. W. E. Abbott, Wingen.

The discussion upon this paper was adjourned to a future meeting.

3. "On the Increasing Magnitude of Eta Argus," by Mr. H. C. Russell, B.A., F.R.S.

Questions were asked by Messrs. Trevor Jones. E. A. Baker, and J. U. C. Colyer, to which Mr. Russell replied.

4. "On a Simple Plan of Easing Railway Curves," by Mr. Walter Shellshear, Assoc. M. Inst., C.E.

A discussion followed, in which Messrs. F. B. Gipps, J. Trevor Jones, and Professor Warren took part.

5. "Indigenous Australian Forage Plants (exclusive of grasses) including Plants injurious to Stock," by Mr. J. H. Maiden, F.L.S.

The thanks of the Society were conveyed to the various authors for their valuable papers.

The following donations received during the month of May were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF MAY, 1888.

BATAVIA—Kon. Natuurkundige Vereeniging in Nederl Indië
Natuurkundig Tijdschrift voor Nederlandsch-Indië,
Deel xlvii., 1887. *The Society.*

BOSTON—American Academy of Arts and Sciences. Pro-
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FLORENCE—Società Africana d' Italia, Sezione Fiorentina.
Bullettino, Vol. iv., Fasc. 1 & 2, 1888. *"*

FRANKFURT A.M.—Senckenbergische Naturforschende
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HOBART—Royal Society of Tasmania. Abstract of Pro-
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- MELBOURNE**—Field Naturalists' Club of Victoria. *The Victorian Naturalist*, Vol. v., No. 1, 1888. *The Club.*
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- TRIESTE**—Osservatorio Marittimo di Trieste. Rapporto Annuale per l'anno 1885, Vol. ii. *The Observatory.*
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- WASHINGTON**—Chief of Engineers U. S. Army. Annual Report for the year 1886, Parts i., ii. & iii. *The Chief of Engineers.*

AN IMPROVEMENT IN ANEMOMETERS.

BY H. C. RUSSELL, B.A., F.R.S.

[*Read before the Royal Society of N.S.W., July 4, 1888.*]

ONE of the most interesting and practically important questions in relation to wind, is what is its maximum velocity or pressure, for the one depends on the other. I need hardly say that many attempts have been made to devise instruments capable of answering that question. It has been generally admitted that existing Anemometers using Robinson's Cup are unequal to the task, because a gust lasts but a few seconds, often not more than five or six, and the recording parts made to register an hour's work on $\frac{1}{2}$ an inch or 1 inch of paper will not shew satisfactorily a gust lasting 10 seconds, that is $\frac{1}{360}$ part of an hour; or, in other words, if one could measure such a gust, it would be $\frac{1}{360}$ part of an inch on the paper, and the smallest error in measuring becomes so magnified when the measured velocity in 10 seconds is converted into velocity per hour, that results are rendered very uncertain. Pressure plates have also been tried in every form, but it is found the results are not satisfactory, because when a gust of wind coming along at a velocity of say 50 miles an hour strikes a pressure plate, it has just the same effect upon it as if it were a hammer striking it a blow: it sets it into rapid motion which by acquired momentum carries it much further than it ought to do. Now Robinson's Cups are free from this defect, and although not without drawbacks, they are in my opinion the best means we have of recording gusts of wind. Of course the open cup, like the pressure plate, is struck by the advancing gust, but at the same moment the same gust strikes the back of the opposite cup and resists any tendency to run away, and it seemed to me that what was wanted was a means of recording with all possible accuracy, the interval of time which the cups took to run a given number of evolutions, and I have accomplished this by putting in a series of pins in the first wheel, so that they make an electrical contact on a light gold spring for every 10 revolutions of the cups. So far there is nothing new. Many Anemometers have been made to record by electrical contacts. The point that I think is new, is that these contacts are recorded on either of the astronomical chronographs, so that the interval between two contacts can be determined with certainty to within one-tenth of a second or even less. The intention is to use this method only

for very strong winds, the Observatory Anemometer has an ordinary scale of 1 inch of paper to the hour, which may be increased to 2 inches, and this is quite enough for all ordinary winds, and more than it is usual to have in Observatories. The new method is one that can at any moment be put into operation by turning an electrical key, and at all other times it is at rest, and costs nothing either in paper or battery force.

DISCUSSION.

Professor THRELFALL asked if it were possible to calculate wind pressure.

MR. RUSSELL :—Not satisfactorily, but a certain rule is generally adopted. There is no question perhaps which is more discussed nowadays as to what is the actual pressure of wind. All the attempts to record the pressure of the wind on any pressure plate have practically failed for several reasons: first, owing to the recoil of the wind that strikes the plate its surface is virtually extended, and gusts at a velocity of 60 or miles an hour or 100 feet in a second strike the plate as if it were struck a blow from a hammer. I have found in an ordinary north-easter, where the wind was not blowing more than 30 miles an hour, that some of the gusts would strike the plate, and make it appear that the velocity was 90 miles an hour, and I was so impressed with the uncertainty that I ceased to trust pressure plates. I think the system called Robinson's Cups is as accurate as any for measuring the velocity. They are subject to some small correction in some cases and not in others, and there is this to be said in their favour: if we measure by such a system as that, we are measuring by an apparatus that can be reproduced hereafter with certainty, and we at any rate get a measure on an uniform system, and if ultimately it is found that the ratio now assumed to exist between the cups and the velocity of the wind be proved incorrect, it nevertheless will be possible to apply the correct ratio to the observations which are now being made, as to the possibility of determining the pressure of the wind by other means. About 10 years since, a railway engine was blown right off the rails in America—a heavy freight engine, and the question as to what pressure of wind was required to blow it over was investigated, and it was found that nothing less than 95 lbs. to the square foot would have that effect; and there are many similar cases in which the wind has actually exerted pressures greatly in excess of what is often assumed to be its maximum.

MR. J. S. MITCHELL :—Many years ago in Tasmania I was very much interested with a very complete arrangement they had at the Observatory for measuring the strength of the wind and the rainfall, and I took myself to make one. I noticed that the

pressure plate for measuring the strength of the wind rested upon springs, so that when the wind blew upon the pressure plate against the springs, by a simple contrivance a pencil marked on the chronograph the strength of the wind and the exact time when it occurred. But it always appeared to me that these springs were not fitted with the mechanical appliances that should be applied to them, because we very well know that if we strike any substance resting upon springs, there is a kind of impulse given to it which scarcely measures the exact force of the blow. I do not know whether any other contrivance has been adopted for this Anemometer or not, but I had an idea at the time (I did not finish this Anemometer I was about to construct) that another contrivance would measure it better, and that was by having a chain weight attached to it. I would ask Mr. Russell what improvements have been introduced since the pressure plates rested on springs.

Mr. RUSSELL :—A great many methods of supporting the plate have been tried, but the one most in favour is hanging the plate on four springs, thereby endeavouring to get rid of friction ; but all the methods are subject to the defect I pointed out, that these violent gusts come along and have the effect of striking the pressure plate like a hammer. It is quite recognised that it does not record the pressure of the wind exactly. Some of the effects of the pressure of the wind are almost incredible. I have an account of a tornado which passed through the bush near Cobar. It cut a narrow lane through the bush, breaking off short every tree in its path, some of them 18 inches in diameter ; shrubs were torn up by the roots, and the tops of large trees forced along the ground after they had fallen, so making grooves in the ground like a plough, and the circular motion of the wind could be seen in the arrangement of the fallen timber. If such a storm ever passes over Sydney there will be many wrecked houses. We know nothing of the velocity of the wind in these terrible tornados. Anemometers made light to record ordinary storms are broken directly by such violent winds, and we can only judge of the velocity by the force shewn in breaking great trees, destroying houses, &c.

Hon. G. H. Cox :—Can Mr. Russell give even a guess as to the enormous velocity of the wind to create such destruction as that ? I can remember many years ago where in a track for 20 miles through the bush the trees were twisted off. What would be the velocity of the wind to cause such enormous destruction as that ? I mean a velocity not only to turn over an engine but houses almost in the streets of the city.

Mr. RUSSELL :—I am afraid I could not give a guess. We have records which shew that the wind must have exerted a

pressure of 95 pounds on the square foot, as just mentioned by me, in order to overturn a railway engine, and other instances of like kind ; but it is more than probable that the force exerted by the wind in a tornado, which breaks off large trees 18 inches in diameter, is much greater, but it has never been measured.

Mr. MANN:—I was in a storm many years ago. I saw it coming up from the southward. I took refuge in my house. There was a large tree at the northerly end of the house. The cyclone twisted this tree and it fell to the southward. It fell over the house and smashed everything to the ground. I went to the door and got out. A quarter-of-a-mile off there was a camp of blackfellows. Their gunyahs were upset. The storm went on and twisted the head off one of the gigantic trees three or four feet in diameter, and the head of the tree which must have weighed 200 tons, was suspended in the air off the ground before it came to the ground.

The PRESIDENT:—We are much indebted to Mr. Russell for his paper and the interesting discussion it has evoked. As the time is going on, I will now call upon the Hon. Secretary to read the next paper. We are all sorry to feel that the author of this next paper is an invalid, and suffering from the injurious effects of his travels, and therefore unable to be present.

ON THE ANATOMY AND LIFE HISTORY OF MOLLUSCA PECULIAR TO AUSTRALIA.

[With Plates.]

BY REV. J. E. TENISON-WOODS, F.L.S., F.G.S.

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THE Mollusca of the Australian coast are sufficiently peculiar to entitle the region to be considered a geographical province. Yet it must be acknowledged that the distinction, though well marked in some respects, is not so peculiar or abnormal as in other sections of the Animal or Vegetable Kingdom. The exceptional characters of the land mammalia, for instance, are truly extraordinary, while of the flora it may be said that volumes have been written about it, and yet volumes must still be written ere the subject be fully unfolded. In the seas and in the rivers, in other departments of the Animal Kingdom multitudes of marvels meet us, all of so strikingly an anomalous kind, that Australia well deserves to be considered a Zoological region, singularly apart from the rest of

the World. As we descend in the scale of life, however, this character becomes less marked, and amongst the Mollusca, though still evident, it is not strikingly apparent.

If we examine into the question, as to what the peculiar features of the Australian Molluscan region are, we find them to consist:—

1. In the possession of a few remarkable genera which are not found in other parts of the World. These contain but few species for the most part.

2. In the possession of abnormal forms of genera which are found elsewhere.

3. In possessing living representatives of extinct fossil forms of Molluscan life, which have played an important part in the earth's former history. Australia has in several other sub-kingdoms remarkable instances of these "survivals" which may be said to be the specialty of its Zoology.

4. In the singular and unaccountable possession of genera and species, which are only known in provinces a great distance apart.

5. In the possession of extraordinary organs in a few instances, such as have been only known to a limited extent amongst Mollusca generally, though not confined to Australia. This peculiarity will be the subject of the inquiries and experiments recorded in this paper. It should, however, be borne in mind, that these organs may become less and less extraordinary as the animals elsewhere are more carefully and extensively studied.

Having pointed out the peculiarities, it must be added that they only affect the anatomy and life-history of Australian Mollusca to a very slight extent: that is to say, the dissections and life observations reveal nothing, or scarcely anything different from what is found amongst Mollusca elsewhere. Thus the dissection of our fresh-water *Unio*, or our salt-water oyster and sea mussel, show that they are, in all but the most trifling particulars, identical with similar animals in Europe. Or, again, a careful examination of the animals of our marine periwinkle or common garden slugs or snails gives us the same organs, disposed in the same manner as the familiar Mollusca of the same kind elsewhere. Our *Unio* has the same peculiarities of the cardiac region, with the outer gill distended with *Glochidia* or young Mollusks whose initiatory life-history is there unfolded before us. The buccal mass of our snails has the same arrangement of the protractor and retractor muscles; the Radula is of the same type, and we find precisely similar distinctions between the dental formula of the various genera. In the course of some years observation, anatomical and microscopical, and in observations on the habits of species, naturalists have come to the conclusion that nothing unusual in these directions is revealed to the observer in Australia. If any lines of investigation are open to the anatomist,

microscopist, or zoologist, they are such as are equally open to observers elsewhere. This at least is a fact of some interest. It is a negative result, yet requiring more extensive observation than any other path of discovery. I wish to record it here as one result of years of observation, pursued under what must be admitted were exceptional advantages. Having been in the midst of the living animals, and having visited in succession almost every part of the Australian and Tasmanian coasts, I have had ample means of ascertaining what are the facts of the case.

In recording the above conclusions, it must not of course be forgotten that there are exceptions to this uniformity, and these are of a singularly interesting kind. As an illustration of what is meant, let us take the instance of *Trigonia*, which, as most people are aware, is a "survival" in Australia of a few species of an almost extinct family, but one which played a most important part in far distant geological times. Now, when Prof. Huxley visited the Australian coast as Assistant Surgeon to the "Rattlesnake," in 1849, he made a special study of the animal of *Trigonia*, which had been previously described by Messrs. Quoy and Gaimard, but much too briefly. The result is published in the "Proceedings of the Zoological Society for 1849," p. 30, but reveals nothing of any great importance. Messrs. Quoy and Gaimard remark that the disposition of the mantle and the absence of tubes, show a resemblance to the anatomy of the genus *Nucula*, from which, however, it differs by the disposition of the gills and the brevity of the oral appendages. No other information was obtained, and as far as any bearing on Molluscan problems, it was very disappointing. But if the study of the soft tissues of the animal was barren of results, it was not so with the shell. Anyone who has examined the very beautiful and attractive looking valves of the Sydney species *Trigonia lamarckii*, Gray, or the much larger Tasmanian species *T. margaritacea*, Lam., will have noticed the peculiar silky lustre on the outside surface, not unlike "shagreen," but much finer and not so rough to the touch. Mr. Woodward in his "Manual of Mollusca," draws attention to this, and says "that the epidermal layer of the recent shells consists of nucleated cells, forming a beautiful microscopic object." (2nd Edit., p. 431.) The so-called nucleated cells will be shown hereafter to be sense-organs of an elaborate character, and the shell will be seen, from the investigations disclosed in this paper, to be a most interesting object, fully sustaining and even surpassing the interest connected with its geological relations.

It must also be noted that the peculiarities of the Australian Molluscan Province, whatever they are, are most visible upon the south coast and in Tasmania. There are two elements which mingle with the Australian Marine Molluscan fauna, and which

contribute to modify its separate character. These are the fauna of the Indian Ocean and that of the Pacific. According to Mr. Woodward's map of the Molluscan provinces, the Australian and New Zealand Marine Mollusca are united together; but with the exception perhaps of one genus named on the map (*Rotella*), all of the genera mentioned are equally common on the east Australian coast. While admitting the difficulty of entering into detail upon a small map, or indeed any map, it must be said that the information generally given on these subjects has been hitherto misleading.

On the north coast the fauna is that of the Indian Archipelago, into which the Australian element enters very slightly. By North Australia I understand the north-east and north-west coast within the tropics. On the coral reefs of the Great Barrier Reef one sees the same, or nearly the same shells that are exposed for sale in the sampans of Singapore or Penang. The relative proportions seem to be the same. In North Borneo and the adjacent islands one sees the same Marine Molluscan fauna. In fact, it would be very difficult for even an accomplished expert to say whether a collection of shells was made on the Barrier Reef, on the coast of Borneo, or in the Straits of Malacca. Indeed, the differences between North Australia and the Philippine Islands in the fauna we are dealing with, are mostly to be seen in the small or minute shells, and one or two species. The large and showy cones, Trochus, Turbos, Nautilus, Olives, Thorny Woodcocks, Clams, Pearl-oysters, &c., are the same in both places and all through the intermediate region. A very few species are local, and probably all but the professional conchologist would regard them as no more than varieties. This Indo-Malayan fauna may be said to extend on the eastern coast as far south as Cape Byron, the most easterly point in Australia, which is considerably outside the tropics. The reason for this is the warm current which extends along the coast from the equator. I am judging by the fauna alone when I say that I believe this warm current is deflected from the land gradually outside the tropics; but it must make a sudden turn to the eastward, for, at Lord Howe's Island, which is almost due east from Sydney, a tropical marine fauna flourishes, with reef-building corals such as are not found anywhere south of Cape Byron, on the East Australian coast.

But even as far as Port Jackson and to the south of it considerably, some few characteristically tropical species are found. Thus *Typhis arcuatus*, Hinds,* *Nassa coronata*, Lamarck, *Mitra pacifica*, Reeve, *Turbo squamosus*, Gray, *Buccinulus coccinatus*, Reeve, *Tellina striatula*, Lamarck, *Chione marica*, L., all distinctly

* This is found as far south as Tasmania.

tropical shells belonging to the Malayan region, have been dredged in Port Jackson.* The well known tiger-cowry (*Cypræa tigris*, L.), *C. arabica*, L., and *C. vitellus*, L., all come within a short distance of Port Jackson, though they are not common. *C. annulus*, L., I have found on the extreme south coast of Tasmania.

On the west coast of Australia, the influence of the tropical seas extends much further to the south, and though as the south-west Cape Leuwin is approached the Australian element begins to manifest itself, the general character is tropical with the Indo-Malayan elements predominating. This need not surprise us, when we find that such a typical tropical shell as *Fusus colosseus*, Lamarck, occurs at Swan River, W. A., and regular reef-building corals form the dangerous reef of Houtman's Islands (S. Lat. 28° 30' about). A collection of shells from the neighbourhood of Swan River contains so large an admixture of forms common to the Indian Ocean, and so few proportionately peculiar to Australia, that the region can hardly be said to belong to other than the very boundaries of the Australian Province.

The characteristic Australian fauna in the Marine Mollusca is best seen between the Australian Bight and the extreme eastern end of Bass' Straits. It is also found in Tasmania; probably more typically there than in any other seas.

The characters of the Australian region may be thus described:—The possession of peculiar genera, such as *Struthiolaria*, *Macrochisma*, *Macgillivraia*, *Amphibola*, *Trigonia*, *Chamostrea*, *Myadora*, and *Myochama*. The above are not found beyond Australia and New Zealand.

The possession of peculiar forms of well-known genera, or else genera which, if found elsewhere, are only sparingly represented or rare; such as *Phasianella*, *Elenchus*, *Bankivia*, *Rotella*,† *Scutus*, *Risella*, peculiar and abundant volutes, *Fasciolaria*, *Crossea*, *Siphonaria*, *Gadinia*, *Anatina*, *Anatinella*, *Pandora*, *Crassatella*, *Cardita*, *Cypricardia* and *Mesodesma*.

To these must be added the Brachiopoda, which are perhaps better represented in Australia than in any other region. They include *Terebratulina*, *Terebratulina*, *Waldheimia*, *Terebratella* (fossil only?), *Magassella*, *Megertia*, *Krausinia*, *Lingula* (three sp.), &c.

The survival of the genus *Trigonia* has already been dealt with; but it derives a greater interest from the fact that we find *Trigonia* represented in tertiary strata by different species from those at

* J. Brazier, Proc. Linn. Soc., N.S.W., Vol. iv., p. 428.

† Found also in India, the Philippines, China, and very common in Japan, but in the Southern Hemisphere confined to New Zealand, and therefore not strictly speaking Australian.

present existing. We cannot enumerate in the Australian fauna a living *Pleurotomaria* as in the West Indies ; but it survived in this region until recent times, as we have a fine tertiary fossil belonging to the genus.

Cephalopoda are well represented in the Australian region. The only peculiar genus is *Pinnoctopus*, a very rare form which was discovered by Messrs. Quoy and Gaimard on the coast of New Zealand, and which is described by them in the second volume of the "Voyage of the *Astrolabe*"* (p. 27, pl. 6, fig. 2). I am not aware that any specimen was ever found except that which was captured on the voyage of the "*Astrolabe*" off New Zealand, which was three feet long. The genus is characterized by the broad wing-like expansions along the sides, which extend in front and envelope all the body. *Spirula* is another genus not confined to the Australian region, but more plentiful on the coasts of Australia and New Zealand than elsewhere, where thousands may be gathered on the beach. The animal is also not uncommon, though perfect specimens are rare. It was a scarcity amongst naturalists, the published descriptions having been derived from one specimen brought home from New Zealand by Mr. Earl, and figured by Mrs. Gray in the "Annals of Natural History," and another described by M. de Blainville. "Mr. Crouch procured a fragment, and an injured specimen was obtained during the voyage of H.M.S. '*Samarang*,' and served Prof. Owen for an elaborate memoir on its anatomy." (Adams, op. cit., Vol. i., p. 44.) There are on the Australian coast many other species of Cephalopoda, such as the Paper Nautilus or *Argonauta*, *Sepia*, several species of *Octopus*, *Sepiola*, *Onychoteuthis* and *Ommastrephes sloanii*, the gigantic cuttle-fish, whose arms are long and powerful enough to drag down large fishing boats at sea.

Some of the genera of the Australian province are not only exceptional types; but while they are found in Australia they are not confined to it, and are only met with elsewhere at a considerable distance, such as *Solenella* of the family of Arcadæ, which occurs in Australia and again at Valparaiso, *Panopæa* of the family Myacidae, which is found in Australia, and similar species in Japan, Norway, the Mediterranean, and the Cape of Good Hope. I have obtained a living species in Tasmania, and Mr. Brazier records one from Port Jackson. *Bankivia*, a singular genus combining the characters of several genera, nacreous and non-nacreous, which is one of the commonest littoral shells in Bass' Straits, and which is found also at the Cape of Good Hope. *Solemya*, another of the Arcadæ, which is said to occur in Australia and in the Mediterranean; *Trophon*, which is common

* See also Adams' "Genera of Recent Mollusca," Vol. i., p. 20, pl. i., fig. 3; D'Aubigny "Mollusques vivantes et fossiles," pl. ii.

to Australia and Fuegia. Mr. Woodward gives other instances, such as *Monoceros*, *Assiminea*, which however must be founded on some mistake. It is almost needless to say that the earlier works on natural history are not to be relied upon for the habitats of their Mollusca, a large number of species having been attributed to Australia which we do not possess, and many Australian species having been attributed by mistake to other countries. This is certainly the case with regard to these two genera.

The number of species common to S. Australia, Tasmania, and other countries, is relatively small. I do not know of many instances of Marine Mollusks common to Europe and Australia; though it is probable, as far as my observations go, that many species which are regarded now by naturalists as distinct, are in reality only modified varieties of species which are common to Australia and other countries, perhaps even Europe. I have always thought that some of the littoral shells, such as limpets, are so modified by climate that their specific identity is lost sight of. I believe that one species of *Acmæa* (*A. marmorata*, T.-W.) has been traced by me from the extreme south of Tasmania through the tropics, Indian Archipelago, China, and so on, even to Japan. What I regard as *Littorina mauritiana*, Reeve, is common to the Mediterranean and Australia, though some naturalists dispute this. *Littorina*, or *Tectarius pyramidalis*, Quoy, which is best represented about Port Jackson and the Heads by large specimens, has also small representatives in the Philippines and in the Malay Peninsula.

The following is a list furnished me by Mr. Brazier of species of Marine Mollusca common to Europe and Australia :—

Crepidula unguiformis, Lamarck. Found in Port Jackson, on the entire coast of America, and in the Mediterranean.

Crepidula aculeata, Gmelin. Port Jackson, southern coast of America, S. Africa, India.

Triton costatus, Born, = *olearium*, Angas (non Linn.). Coast of New South Wales, Victoria, Tasmania, Mediterranean.

Philippia lutea, Lamarck. Port Jackson, Coast of New South Wales, Victoria, Tasmania, Mediterranean Sea.

Pileopsis ungaricus, L. Hobson's Bay or the Melbourne Heads (Bracebridge Wilson) on the authority of Prof. Tate.

From the foregoing remarks it will be seen that the Australian Molluscan province, though possessing special peculiarities, does not offer to the anatomist and physiologist any very exceptional features for investigation. Yet there still remains a sufficiently wide field of research to provide ample material for such an essay as that for which the "Royal Society of New South Wales" has offered its prize. Let it be observed, however, that the mere enumeration of anatomical or physiological features would result

in nothing interesting; besides occupying an immense space to no purpose. I shall confine my observations, therefore, to those lines of inquiry to which my own attention has been specially directed, and which have proved most fruitful in interesting discoveries.

For the convenience of reference, I shall make three divisions in the Molluscan Sub-kingdom, namely:—1. Marine Mollusca. 2. Fresh-water Mollusca. 3. Land Mollusca. This division, which is of course not zoological, is more convenient for me, for reasons which will appear as we proceed. I shall deal in this essay with the Marine Mollusca almost exclusively.

The Molluscan character of any portion of the Australian coast differs according to its climate and situation. In no country perhaps in the World, are there more long stretches of low sandy coast, without rocks or indeed anything but sand-dunes. This is especially the case on the coast of N. Australia, where the shore is so low, and the sea so shallow, that except in a few places no vessel of any size can keep within sight of it, and it is not often visible, except by the smoke of bush fires, at a distance of four or five miles. In such regions, very little is to be seen of littoral Mollusca. A few bivalve shells are scattered along the sand-dunes, the species varying according to the locality. On the north coast these are:—*Mactra*, *Tapes*, *Cytherea*, *Asaphis*, &c. On the south coast such regions are especially rich in *Donax*, *Venus aphrodina*, Lam., *V. lamellata* Lam., (which probably extends as far as China), *Mytilus*, &c.

In places where the shore is rocky, there is a complete change in the fauna. Within the tidal-marks, but generally in the highest part of them, we find a *Patella* outside the tropics, and a *Nerita* within tropical regions, though Patellidæ are not wanting also, with *Acmæa*, *Planaxis*, *Littorina*, *Monodonta*, *Chiton*, &c. On the south coast we have *Patella*, *Acmæa*, and *Siphonaria*, with two or three species of *Littorina*, *Trochocochlea*, and *Risella*. These species are generally out of the water. Within the tropics, amongst the mangrove swamps, there are the usual brackish-water species of *Nerita*, *Cerithiidea*, *Telescopium*, *Melampus*, *Auricula*, *Pythia*, *Cyclas*, *Littorina scabra*, L., and rarely *Austriella sordida*, a genus of the author's.*

The above named littoral species offered such special facilities for study, that from the very first they attracted my attention particularly. There are, as all those moderately acquainted with the subject are aware, under the guise of shells presenting no

* See Proc. Royal Society of Victoria, Vol. xvii., 1881, pp. 80-83, pl. 1, figs. 10-11, "On Some New Marine Mollusca." The new genus *Austriella* is distinguished as including thick non-nacreous shells, with a smooth, arcuate, hinge margin, without teeth, with a persistent periostraca.

external differences except those scarcely specific in character, not only distinct genera, but even three distinct families. In this there is nothing very surprising, if we remember that the early condition of embryonic shells is cup-shaped. This persists in some by their growing regularly, and thus they have in the adult condition a more or less elevated and conical shape. The difference between these forms and the whorled, spiral, or heliciform shells, is derived from the fact that the embryonic form develops disproportionately in one direction. The mode of this development gives rise to all those modifications of form which are met with in the Mollusca. From this it may be remarked in passing, how useless any system of classification must be which confines itself exclusively to the form and color of the shell. Thus restricted, conchology was for a long time unworthy of the name of a science.

But while we recognize the great anatomical differences which separate animals which resemble one another in the forms of their shells, we must note the fact that similarity of habits or the conditions of life lead to other resemblances of an important kind. This will be seen from the observations I shall have to make on the eyes I have found in the shells inhabiting the littoral regions. These seem to be in number, size, and disposition, very similar in all the littoral shells that congregate about the tidal marks. I have found that these organs of vision are reproduced in the same manner, or to some extent the same manner, when the shell is subject to much erosion from the alternate action of the air, sun, and salt water. I have found this the case particularly in the genera *Patella*, *Acmæa*, and *Siphonaria*, all conically shelled species: as well as the spiral univalves *Trochus*, *Trochocochlea*, *Senectus*, *Littorina*, and *Risella*. These instances will be referred to in detail further on.

Before proceeding with this matter of the shell, it is advisable to deal with some points of classification, which illustrate in the conically shelled species important physiological and anatomical principles. We find amongst the conical-shelled littoral species, three or perhaps four forms of branchiæ or respiratory organs. In *Patella* they are a fringe round the foot, between it and the mantle. It is interrupted only for a short distance where the head protrudes. In *Acmæa* the gill forms a single pectinated plume at the back of the neck. In *Siphonaria* there is a lateral respiratory orifice leading to a chamber which is covered by a portion of the mantle, forming a pulmonary cavity like that which obtains amongst the slugs and snails, or rather like those Mollusks which are destined to breathe both air and water. In the case of *Siphonaria* there is a gill in the pulmonary cavity.

The function of *respiration* is generally speaking a function of the integument, and is said to be a gill or lung when it is specially

localized. This does not always happen in similar portions of the animal, nor can we regard all the organs which appear to be gills as morphologically identical (Gegenbaur). Moreover, instead of a specialised gill, a modification of the organ of respiration may be found in a respiratory canal system, which is developed in the walls of the mantle cavity. In some Gastropods, according to the author just quoted, this network of canals extends beyond the gills into the neighboring parts of the branchial cavity, which are thereby enabled to take part in the respiratory function. In this way the mantle cavity is adapted to taking in air and becomes a lung. An organ of this kind is found in various forms in very different families of Mollusca. It enables the animal to breathe both air and water. The following observations on this subject, as illustrated in an Australian Mollusk, were made by me in Tasmania. The species referred to is *Siphonaria denticulata*, Q. and G. The shell is irregularly oval, with a protuberance on the siphonal side, with 40 to 50 fine ribs of lighter and darker colors. Animal dull brown, with numerous small light spots of varying size; foot yellowish, shading to orange near the head; mantle brown, fringed at the edge with whitish and black spots. When the mantle is contracted the black spots seem to be the points where it is drawn in. Head, a large and many-lobed mass, forming a cup-like expansion round the very small mouth; no eyes visible, and, though they are represented in Messrs. Quoy and Gaimard's figures of *S. diemenensis*, Quoy, I have never been able to detect anything but a single black dot of varying position on one of the lobes of the head. Above the foot on the left side of the animal is a lobe which forms a kind of semi-circular tube, closely pressed to the shell, and here the mantle is not visible. This tube is the siphon, and is lobed so as to be capable of a kind of bipartition which probably divides the orifice into an excretory as well as respiratory duct. This lobe of the foot acts as a kind of operculum, closing the orifice when necessary. If placed in the open air the siphon tube opens at once, and it is always open when the animal is taken from the rocks which it inhabits, and which are never long covered by the tide. On placing weak carbonate of ammonia about an inch from the orifice, the animal emitted bubbles of air and showed signs of distress by movement and by pouring forth water from the mantle. On immersing in water animals long exposed to the air, many bubbles of air rapidly escaped, and the siphon became tranquil and full of water. In this state the animal continued many days. Carmine dropped into the water, gradually spread out, and was drawn almost imperceptibly into long threads or currents towards the siphon, and then much diluted and in fine streaks. From these facts we may conclude that respiration is accomplished by no muscular

movements, but probably by a ciliated portion of the lung cavity. By the word siphon of course is understood merely the pulmonary orifice. Generally speaking the word has quite another signification in reference to the Mollusca; but its use in an irregular sense has been customary amongst naturalists when dealing with this genus.

Accompanying this peculiarity in the organs of respiration, we have a Radula of a type which belongs to the pulmoniferous Mollusca in both the land and fresh-water genera. In *Siphonaria diemenensis* or *denticula* the buccal mass is red and fleshy, in which two long, thin, rather broad, cartilaginous jaws are imbedded. Amid these the broad Radula is spread, working almost perpendicularly, with a very slight movement backwards, as far as I could ascertain in the few opportunities which the shy and sluggish animal gave me of observing. The œsophagus is a bright orange-yellow, and terminates at the distance of about 20 mil. in a sac of the same colour. The Radula soon becomes a tube enclosed in membrane. It does not follow the œsophagus, but curls round and projects as a closed hyaline tube outside the buccal mass into the cœlom. When the animal is wounded it emits a viscid milky fluid of apparently a different character from the blood of Gastropods.

The Radula with careful manipulation may be easily extracted and spread out. It is not difficult to clean it from the attached membranes, and when spread is about 8 mil. long by 3 broad. It is a series of curved lines of teeth diminishing in size from the centre to the margin. The teeth have a broad crescentic edge, which increases in width downwards, and are fixed upon the membrane. The teeth gradually diminish outwardly to a mere faint line of curved tubercles. The appearance of the whole is more like a series of combs with long curved teeth. There appears to be, properly speaking, no plate from which each tooth projects, and the central tooth from which each row diverges in a curve. A line is rudimentary.

This correspondence between the organs of respiration and the Radula, would seem to justify those naturalists who wish to make the structure of the dentition a leading feature in the classification of Mollusca. There can be no doubt that in this instance, the dentition is an organ of far higher importance than the shell: in fact the dentition goes a very long way in giving a clue to the habits of the animal; but it is not an indication in every respect. Thus, if we should say that the pulmonary sac for breathing air or water has a certain form of Radula accompanying it, we find organs of respiration associated with almost every form. The common periwinkles on our coast, *Risella melanostoma*, Gmelin, and *Trochocochlea trinitata*, Quoy and Gaimard, afford us illustrations of this. In both of them respiration is performed

by means of a gill-plume; but if the Radula of the first-named species is examined in its natural position, it will be found to be exactly like that of the common periwinkle of the British coast. It is a long, slender thread, five or six times the length of the whole animal, and strange to say it lies sheathed in membrane, and neatly coiled up like a piece of rope at the back of the head. This peculiarity is shared by all the periwinkles known to me on the Australian coast, though extending to different genera or sub-genera such as *Risella*, *Tectarius*, and *Littorina*. Without stopping to enquire into this peculiarity, for which many reasons might be given, I may say, that the structure of the Radula itself is that of the British periwinkle expressed in the formula $\frac{3.1.3}{\infty}$. There is a figure in Woodward's "Manual of Mollusca" (2nd edit., p. 252), of the European periwinkle, which does not quite correspond with any of our Australian species.

In *Trochocochlea teniata*, Lam., the type of Radula is entirely that of the turbinate Gastropods or nacreous trochoid shells, the RHIPIDOGLOSSA of Troschel: that is to say the central large tooth with five laterals and an indefinite number of lanceolate uncini decreasing from the centre to the edge of the Radula, until they become hair-like hooks set together like the plumes of a feather.

In *Acmea septiformis*, Q. and G., or *A. marmorata*, Tenison-Woods, there is a gill-plume at the back of the neck as already stated; but the type of the shell is the conical one of *Patella* and that also is the type of the Radula. This is a long, deep brown ribbon, with pairs of long central teeth and no uncini. (See pl. iv., fig. 3. *Patella tramoserica*, pl. iii., fig. 2.)

So that in these three instances we have illustrations of two different organizations, in which the organs seem to be associated according to no definite rule. In the one case the Radula would seem to follow the structure of the branchial apparatus; in the other a certain form of Radula seems to belong to a certain form of shell, while the branchial arrangements are quite different.

BRANCHIAL ORGANS.—The type of the gills or branchiæ, which in some form or another are placed in the cavity between the mantle and the foot, is a series of filaments forming separate lamellæ. I just refer to the fact that the gill is a differentiation of the integuments, and is superficial primitively, becoming placed in a special cavity by being covered by another fold of the integument. Each gill-lamella is developed from a row of processes growing close to one another and remaining separate occasionally, but in most cases growing together and forming a plate. The union, however, is not complete. Fine clefts exist at intervals between the filaments through which the water passes. "These filaments are not simple prolongations, but loops, so that

they enclose a space (intra-branchial space); when the gill-filaments grow together, this space traverses the whole of the gill-plate, and communicates with the exterior by means of the clefts between the filaments. The water which enters by these clefts is collected into a canal at the point where the plate is attached, and is carried by it to the hinder end of the body. There are chitinous rods in each of the gill-filaments, which form a special organ of support." (Gegenbaur.) This quotation will be a sufficient explanation of the observations which follow.

In all the Mollusca that I have examined, I have seen scarcely any exception to this general type of structure; though there is one species in which I have not been able to find it. This is *Cerithium ebeninum*, Brug., to which frequent reference will be made.*

In nearly all the littoral species referred to, if a small portion of the lamellæ is taken, a circulation can be seen for some time after the death of the animal. In *Patella tramoserica*, Martyn, the gill forms a fringe of separate cylindrical filaments round the foot. There is no plate, properly speaking, though each separate filament is a row of rods arranged at right angles or obliquely to the length of the filament. This is a very peculiar structure, and deserves attentive examination. Like all the gill-organs these filaments are richly furnished with cilia. Down each side there is a wide branchial artery, and the chitinous rods pass from one to the other. Between these the blood can be seen circulating, and the cilia in constant movement, causing the fluid to move in two distinct currents along the narrow channels, so that the corpuscles are visible passing in opposite directions or jostling one another as they are hurried to and fro by the action of the cilia. I have seen this action going on vigorously four hours after the death of the animal. The whole surface of the filament, it should be noticed, is studded with minute pores, possibly to permit a more perfect oxygenation of the blood. The pores are apparently smaller than the corpuscles, which are irregular in size and shape, some being many times larger than the pores referred to. The chitinous rods seem to be hollow tubes, darker in the centre from granular cells. The rod continues to the end of the filament, where the rounded ends give to the latter a wrinkled appearance.

A somewhat different structure exists in the case of *Chiton*, where the general plan of the branchiæ is the same; that is, continued round the foot. It is remarkable that there should be such an extensive gill in the case of these genera, while in the genus *Acmæa*, which is a conical shell attaining to nearly the same size, a small gill-plume at the back of the neck comprises the

* Adams in his notice of this animal, in the "Voyage of the Samarang," gives a dissection of *Cerithium*, but avoids all mention of the gills.

whole branchial organs of the animal. For instance, in *Acmaea alticostata*, Angas, the filaments of the gill-plume are extremely long and thin, attached on one side to the branchial artery which is wide, and with a smaller artery running parallel at a short distance, sometimes anastomosing with the main branch which is the shaft of the plume. In the space between the two arteries, the filaments are indistinctly marked and covered apparently with papillæ. Beyond the smaller branchial artery the filaments extend in long curved regular lines to the outer edge, where there is a second artery at which they terminate. Beyond this there is a margin of cellular substance, from which long, narrow, extremely fine filaments extend and seem to be free, attached only to the edge of the plume.

Trochocochlea tæniata, Lamarck, is an interesting example which can be obtained easily from almost any portion of the extra-tropical Australian coast. The gill-filaments are grown together, so as to form a broadly lance-shaped plate. They are very long, but with such small cilia that high powers are required for their detection. The circulating currents I have never been able to see; but one peculiarity is deserving of notice. On the outer edge of the plume there are a few scattered, single, cylindrical filaments, which extend from the free edge about a fourth part of its greatest diameter. These have a kind of spasmodic movement, sweeping round from side to side; and when they are watched with a moderately high power, it will be seen that the tube opens and shuts with a sphincter-like contraction, and a constriction a little within the extreme end. I have not been as yet enabled to ascertain exactly whether this movement was connected with the entry or exit of currents of water, but the general impression left on my mind is that the movement was that of suction, and water was taken into the interior of the gill.

In making examinations of the gills, students need not be restricted to such small species as those mentioned, for we have commonly on our coasts large Mollusca, whose branchiæ will hardly require the aid of a common lens for their dissection and examination, and only that of the microscope will be necessary for minute physiological details. *Haliotis nevosa*, Martyn, *Turbo* (*Senectus*) *gruneri*, Phil., *T. (Lunella) undulatus*, Chemn., are all very common on the south coast, and of large size. I was once fortunate enough to secure a very fine specimen of *Sepia* in Botany. The species may have been *Sepia officinalis*, L., at any rate, it was about two feet long, and was a splendid subject for dissection. The branchial cavity when laid open along the mesial line, exposed a beautiful pair of pinnate gill-plumes at each side of the ink-bag. The pinnæ were given off from a stout stem, which was not unlike in form to the shaft of a feather. The

pinnae supported the lamellae of the usual gill-like pattern. I believe it is not at all uncommon in Botany Bay for similar large specimens to be washed up upon the beach.

Amongst the Lamellibranchiata the gill plates are associated with the organs of locomotion. Thus in *Lima multicostata*, Sow., which is not uncommon on the north-east coast about the Barrier Reef, we find the mantle-margins separate and the inner margin fringed with long tentacular filaments. These are of a deep crimson color, with transverse lines upon them which make them look as if they had spiral lines inside. The animal swims with a gentle opening and closing movement of the valves, making it progress in a series of small jerky movements. The filaments of the fringe are thus always in movement backwards and forwards, and the water is thrown in a series of waves on to the gill-plates, giving a stream of water for respiration such as would be supplied were the animal possessed of a siphon. It is a singularly beautiful Molluscan gill, and a similar species has attracted the notice of naturalists in Britain. Unfortunately a little touch with the hand breaks off the filaments. They form most interesting objects under the microscope, and continue moving for several hours after being detached from the animal.

The gill of our common oyster (*Ostræa mordax*, Gould,) forms an important and valuable subject for microscopists, which is always within our reach. The different filaments are seen to be united, as it is termed, by concrescence. Between each of them there is a double layer of chitinous rods, each layer being separated by a series of cells lined with ciliated epithelium. These are the apertures between the filaments. Besides the chitinous rods there are transverse divisions between the gill-chambers, consisting of horizontal fibres between each of the apertures. The surface of the whole gill is thickly covered with ciliated epithelium, larger on the divisions, and these cilia keep up a continual stream of water. In this species they are of unusually large size.

The gill-plates of some of the families of bivalves are united together. In the Mytilidæ or mussels this union is small in amount, and gives rise to two orifices, anterior and posterior, the larger of which is the anterior one, and this serves as an outlet for the foot, while the posterior outlet allows the excreta and the water which has been used for respiration to pass out. If the common mussel, *Mytilus hirsutus*, Lam., is taken alive and placed in the water, this movement can be watched and the whole process seen distinctly. If also one of the common Arcadæ, such as *Arca trapezia*, Desh., be taken, it will be found that the gills are united posteriorly to a membranous septum. In the common *Trigonia pectinata*, Lam., or *lamarckii*, Gray, the mantle-lobes correspond with the grooves of the shell, so that it appears to be

in plaits which are rounded at the edge ; but the lobes are disunited throughout, nor do they join until they reach the upper surface of the posterior adductor muscle. The gills are united before and behind the foot.

In Section A of Siphonidae there are short siphons. The part of the mantle which surrounds the orifices already spoken of becomes united, and forms a tube which is double or divided at least internally by a partition. In the lower tube the water passes in, being drawn by a movement of the cilia, and passes out again by the upper tube, the current removing at the same time the excreta. In some cases the siphons are short and the pallial line simple, that is without a deep sinus. Of this we have a good example in the common *Chama* (sp. ?) of Port Jackson. In the family Tridacnidae, which is distinguished by having the adductor muscle single and nearly blended with the pedal muscle, the mantle-lobe is extensively united, with however a large anterior opening. There is a small grooved foot near the hinge. The siphonal orifices are surrounded by a thickened pallial border. This genus is well represented in Australia by the large clam *Tridacna gigas*, L., where the size the organs offers special facility for study. It is very common on all the Barrier Reef.

To mention all the various modifications of the siphonal tube which can be studied amongst our Mollusca, would exceed the limits proposed by this essay. It will be sufficient to mention the genera *Cardium*, *Lucina*, *Cyclas*, *Circe*, *Crassatella*, *Cypricardia*, *Cardita*, and *Venus*, all of which have common species on our coasts, and are typically Australian. Nearly all the genera mentioned above have been examined by me, and do not offer anything of special interest. In *Panopæa australis*, Sow., we have probably the double siphons in their highest degree of development, as they are largely protruding from the shell and covered with a thick wrinkled skin. Living specimens are occasionally met with in the Harbour, but they are rare, though the animal cannot be considered uncommon, as single valves are continually found. By digging for them I am convinced many would be obtained, as they are gregarious.

This seems a proper opportunity, as I am dealing with the organs of respiration, to refer to the circulating fluid or the blood of Australian Mollusca. The blood has formed the object of special study by many naturalists. As early as 1846, Dr. T. Wharton Jones read some papers before the Royal Society of London on the blood corpuscle in its different phases of development in the animal series. He found in the blood of the common whelk (*Buccinum undatum*, Lam.), granule cells and nucleated cells essentially similar to those of the blood of Annulosa. In *Mytilus edulis*, L., or common mussel, similar cells were found. The blood of

both species had a tendency, he remarked probably for the first time, to shoot out into amœboid processes. Many other observations have been made, but it will be sufficient now to refer to those of Mr. Ray Lankester "On the Distribution of Hæmoglobin in the Animal Kingdom," read before the Royal Society of London,* and the researches of Dr. MacMunn.† Without detailing all the observations, what refers to this subject may be summarized as follows.

The colour of the blood in invertebrate animals does not belong to the corpuscles, but to the *liquor sanguinis*; but there are many exceptions. The color itself is blue after exposure to the air, due to the presence of a pigment named hæmocyanin, in most cases. On analysis the blood is found to contain traces of copper and iron. Extensive examinations have been made as to the nature of this blood and its coloring matter, particularly in the case of fresh-water mussels, snails (*Helix pomatia*, L., *Lymnæa stagnalis*, Drap., and *Paludina vivipara*, Lam.) &c. Most of these animals have blue blood; though in some this quality does not appear until after exposure.

Dr. Lankester has made special researches on the subject of hæmoglobin in Molluscan blood. He found that it occurred in special corpuscles:—1. In the blood of *Solen legumen*, where it is diffused in a vascular or ambient liquid. 2. In the general blood-system of the pulmonate *Planorbis*. 3. In the muscles of the pharynx and jaws of certain Gastropods, observed in *Lymnæa*, *Paludina*, *Littorina*, *Patella*, *Chiton*, and *Aplysia*. Also in the pharyngeal gizzard of *Aplysia*, being entirely absent from the muscular and other tissues and the blood.

Dr. Lankester found in his investigations amongst Mollusca, that there were many cases of red tissue or liquid in the foot and mantle, and in their nerve ganglia, which might be supposed to be due to hæmoglobin, but are not so, as the tissue or liquid did not give the characteristic bands of hæmoglobin when examined by the spectroscope. The result of all his investigations was that hæmoglobin was found distributed irregularly throughout the animal kingdom, being absent entirely only from the lowest groups. It may occur in corpuscles of the blood or in the *liquor sanguinis*, in muscular tissue or in nerve tissue. It may be present in one small group of muscles, and absent from all the rest of the tissues of the body. He thought that a partial explanation of this arbitrary distribution may be found by reference to the chemical activity of hæmoglobin. Wherever increased facilities for oxidation are requisite, hæmoglobin may

* Vol. xxi., No. 469.

† "On the Chromatology of the Blood of some Invertebrates," Quart. Journ. Micros. Science, Vol. xxv., 1885, p. 469.

be the suitable agent employed. The Vertebrata and Annelida possess a blood containing hæmoglobin, being of greater activity than the Mollusca, which do not possess such blood as a rule. The actively burrowing *Solen legumen* alone amongst Lamelli-branchiate Mollusks and only *Planorbis* amongst Gastropods, respiring the air of stagnant marshes, possess blood containing hæmoglobin. In the former the activity, in the latter the deficiency of respirable gases are correlated with the exceptional development of hæmoglobin. But we cannot as yet offer an explanation for the absence of hæmoglobin from the closely-allied species of *Solen*, and from the *Lymnæi* which accompany *Planorbis*.

Hæmoglobin-bearing corpuscles are, according to the same author, of a peculiar character. When hæmoglobin is absent, other things remaining the same (as with the blood of *Solen ensis*, L.), the peculiar corpuscles are absent also. Such things as colorless corpuscles representative of hæmoglobin do however appear to exist in the case of the fish *Leptocephalus*. In connection with the relation of the colorless corpuscles of vertebrate blood to the red corpuscles, and of the corpuscles of the vascular fluids of Invertebrata to one another and to those of Vertebrates, these facts seem to be important; the colorless corpuscles in one case are only comparable to the colorless in another; the red corpuscles are something apart, which may or may not be superadded.

Dr. Lankester mentions in another place a species of *Arca*, in the blood of which he detected hæmoglobin, and which I believe is of a red color. Without being able to say anything as to the occurrence of hæmoglobin, I wish to record here that one species, very common in all muddy places on the extra-tropical Australian coast, and particularly so in Port Jackson (*Arca trapezia*, Desh., = *A. lobata*, Reeve), has red blood, very like in color and appearance to the blood of a vertebrate animal. When examined under the microscope, the red color is seen to be due to corpuscles with a nucleus exactly like human blood, except that the corpuscles appeared to me to be not quite so proportionately numerous as in the human fluid. There was an absence also of any of the amœboid movements, so well known and so often described. The size also appeared to correspond with that of the human corpuscle with a scarcity of colorless discs.

When a living specimen of *Arca trapezia* is opened, the injury to the tissues, as in the case of the oyster, causes the blood to flow freely, and the heart may be seen to be pulsating at the rate of about 15 or less pulsations per minute. On these occasions it appears like a little vesicle fully injected, and can be easily studied in that position. As already stated, if a piece of the gill is now removed and placed under the microscope, innumerable crowds of

red discs may be seen coursing down the channels around the filaments.

The fact of another species of *Arca* in the Southern Hemisphere having red blood is one of considerable interest, and I trust it will soon be ascertained whether it contains hæmoglobin, of which there can be but little reasonable doubt. The habits of the animal are such as to require some highly oxidizing element. Like *Solen ensis* in Britain, it buries itself deeply in the sandy mud and silt when the tide recedes, and comes to the surface when the water is in. The mud in which it lies buried is so finely lavigated that it can generally sink to considerable depths, and the surrounding ooze must penetrate into every crack and crevice and exclude every particle of oxygen. Under these circumstances it would need, it seems to me, all that hæmoglobin could do for it. The habits of the *Solens* are similar, except perhaps that in burying themselves they seem to prefer sand to mud. Often when a lad I have captured numbers of *Solens* by searching for their place of interment, indicated on the surface by a small perforation like a keyhole. Putting a little salt on the hole, and then a little water, generally brought the animal to the surface. It used to be said that it came up because the salt made it think the tide was rising, but probably as much was due to an unexpected shower bath of strong brine.

There are two species of *Solen* in Sydney Harbour, differing but little from each other; but their blood is red like that of *Solen ensis* in Britain. It may be observed that burrowing alone to great depths is not a habit which necessarily indicates red blood amongst Mollusca. *Natica*, many of the species of *Venus*, *Cardium*, *Mactra*, *Donax*, and many others, are all burrowers, and none of them, as far as I know, have blood different from the usual Molluscan character.

I have not had any opportunity as yet for the examination of the blood of any of our species of *Planorbis*. The red color of its blood has been asserted, contradicted, and re-asserted many times. In Prof. Tate's admirable and painstaking little book on the "Land and Freshwater Mollusks of Great Britain," (London, Hardwick, 1866,) he says, "The species that compose this genus are numerous, inhabit slow running streams, ponds and ditches, feeding on the aquatic plants, and are very sluggish in their movements. A peculiarity possessed by all the genus, may be readily observed by irritating the animal of *P. corneus* or *P. marginatus*, when a purplish liquid is emitted, which is not the blood, for the circulating fluid is colorless," p. 210.

I believe that the one Tasmanian species, and one if not more of the Australian species have colored blood, but I have not subjected the fluid of any of them to microscopic examination.

In a great number of Gastropoda which I have examined, including the following species, I have found red fluids in the buccal masses surrounding the jaws :—*Patella tramoserica*, and the other littoral species already mentioned, such as *Acmaea*, *Siphonaria*, *Risella*, *Trochocochlea*, *Senectus*, many species of *Trochus* : in fact, I do not remember having met with any species in which the buccal mass had not a blood-red color. The appearance around the jaws is just that of raw flesh, but a minute examination shows that the red portions are not universally distributed, but confined usually to the terminations of the bands of muscles. If the buccal mass of any of the Gastropods is placed under the microscope, it is seen to consist of a number of long narrow bands, red at the ends. The spindle-shaped cells are often greatly elongated and band-like in form, surrounded by a membrane. There is no differentiation of those singly and doubly refracting particles, giving the appearance of transverse striation. In all the species I have examined the band-like fibres prevail.*

Before leaving the subject of the buccal mass, it will be well to deal with the cartilages which support the Radula, which in the most of the Gastropods is the only representative of the internal skeleton. In the Trochidae, Patellidae, Littorinidae, and many other families, there are two oblong pieces of cartilage, raised at the edges with a central broad groove in which the Radula lies. The shape of these two pieces of cartilage is somewhat pointed at the extremity, like a tongue in fact. In *Senectus gruneri* there are four pieces of cartilage ; that is to say there are two small pieces added on to the posterior end of each jaw, and working with a hinge-like movement. In other species, the extra cartilage is reduced to a mere tubercle, but there is much variety.

In the Siphonostomata, where the buccal mass is contained at the mouth of a more or less long contractile siphon, the arrangement is very different. Taking *Triton spengleri*, Lam., a common species at Port Jackson, as a type, we find a simple tube of thin cartilage surrounded by two muscular coats, one lining the inside and the other the outside of the much thicker cartilaginous siphon. The cartilaginous jaws in the buccal mass are hood-shaped and meet together over the Radula, a part of which is exposed in a kind of little orifice, and where it works backwards and forwards on the particles of food which are exposed to its action. The hooded cartilaginous jaws are bound round with a series of band-like muscles ; one transverse band passes over and under them about half-way from the orifice or fissure where the hood-like jaws meet.

*Mr. G. Tryon, in his "Introduction to the Study of Mollusca," (Vol. i., p. 90,) says that in *Arca pexata* the blood is red, and is commonly called "the bloody clam." He speaks also of the coloured blood of all the species of *Planorbis*.

- Though the junction of these jaws is pretty close above and below, they seem as it were to strangle the Radula, and make the teeth project out in a kind of point or bunch. One can easily understand when looking at this instrument, how it is that the Siphonostomata are able to bore holes in shells of such an exactly rounded shape. The appearance of the buccal mass is very much in shape like *Teredo navalis*, L., having the same broad, blunt, conical outline. All the Siphonostomata are carnivorous feeders it is said. As a rule the Radula is very short, and is composed of a short series of long hooks with a sharp blade and a broad curve, something like a sickle. The central teeth are broad, simple chisel-like forms. (See Fig. 4.)

Every one who has examined these animals must have noticed the redness of the termination of the tube. If this is inspected carefully, it will be found that there are two distinct muscular bands, crossing each other, both tinged with red blood. From the back of the buccal mass the cesophagus lies loosely in the tube, being fastened underneath by a narrow series of muscular bands which secure it, but give the greatest freedom of movement.

Orepidula aculeata, Gml., is a small shell which is found in Port Jackson, and I believe in most temperate seas of the World, and strangely enough, always as a kind of tenant in the shell-mouth of a *Triton*. It is one of the Siphonostomata, with a shell of inconspicuous color but peculiar slipper shape. The most of the animal is located under the partition which extends half-way across the shell, giving it the appearance of a minute slipper. The animal is beautifully mottled brown and pale yellow over the region of the viscera, and is quite visible through the septum which is transparent. The siphon projects out through this and is conspicuously red. The Radula is of the usual type, such as I have described above; but there is a peculiarity at the base of the sickle-like teeth which I have not observed in other species. At the curve of the shaft there is a row of eight or nine tubercles decreasing in size from the centre.

I may here mention a circumstance connected with the circulation, which I could not more conveniently introduce elsewhere in this essay. I shall have occasion to describe subsequently the mode in which the shell-structure is permeated by perforations and nerve fibres, to an extent which almost destroys our previously received ideas of its compactness and solidity. In some of the sections I have observed small blood-vessels permeating the shell-structure as well. These vessels are of extreme tenuity, not more than $\frac{1}{160}$ of an inch in diameter; but the most singular fact connected with them is, that something like valves are observable at regular intervals all through the length of the transparent tube. I am not aware whether valves

have been noticed in the veins of the Mollusca ; and in these small capillaries, it is the only instance in which I have been able to perceive them. The fact, in any case, has a most special interest as occurring in the shell-structure, where I do not find that any author has suggested the existence of blood circulation. The tubes were ultimately merged in the thickened shell-structure.

MULTIPLICITY OF EYES IN MANTLE AND SHELL.—It is nearly a century since Poli ("Testacea utrisque Siciliæ," p. 153,) noticed the occurrence of certain organs like the human eye in the mantle of *Pecten*. This, after a long interval, was a subject taken up by many observers, and extended to other genera, such as *Arca*, *Pretunculus*, and *Cardium*. In 1877 Dr. Karl Semper published the important discovery that he had made, of eyes in the dorsal papillæ of certain species of *Onchidium*, while it began to be realized that Mollusca generally were better provided with visual organs than had ever been imagined; but the shell was not thought to be the place where they would be found to reside. To use the words of Prof. Mosely, "A Molluscan shell is, moreover, almost the last place in which the naturalist would expect to find eyes, and the Chitonidæ have hitherto in text-books always had the absence of eyes assigned to them as one of the characteristics of their group."

It would be unjust not to mention the labors of other observers in the same field, and therefore the following extract from Prof. Mosely (Quarterly Journ. Microscop. Science, 1885, p. 38,) becomes necessary:—"Middendorf ('Beiträge zu einer Malacozoologia Rossica,' 'Mém. de l'Acad. de St. Petersbourg Sc. Nat.' Ser. iv., t. vi., 1849.) named two distinct layers, of which the shells of Chitonidæ consist, the tegmentum and articulamentum ; and Dr. W. B. Carpenter examined the shells of Chitons by means of sections, and observed the perforate structure of the tegmentum in Chiton, writing as follows: "In Chiton the external layer, which seems to be of a delicate fibrous nature, but which is of extreme density, is perforated by large canals which pass down obliquely into its substance, without penetrating however as far as the middle layer. (Dr. Carpenter has kindly lent me his original sections of Chiton shells, and from what I now know I am able to recognize parts of pigmental eye-capsules in one labelled *Chiton spiniger*)." ("Cyclopædia of Anatomy and Physiology, Article Shell," p. 565.) The late Dr. Gray wrote in his paper on the "Structure of Chitons":—"The greater number of species have a part of the valve which is not covered by the mantle, but exposed. This exposed part consists of a perfectly distinct external coat, peculiar I believe to the shells of this family. The outer coat of these valves is separated from the lower or normal portion by a small space filled by a cellular

calcareous deposit, which is easily seen in a section of the valves. (J. E. Gray "On the Structure of Chitons," Phil. Trans., 1848.) In 1869, Dr. W. Marshall ("Note sur l'histoire Naturelle des Chitons," "Archives Neerlandaises des Sciences exactes et nat." t. iv., 1869,) made a great advance in our knowledge. He found that the tegmentum of Chitons was perforated by a series of fine vertical canals, which open at the surface in a series of cup-shaped apertures, and that these vertical canals open into a series of horizontal canals running in the space between the apposed surfaces of the tegmentum and articulamentum; and that these canals opened on the under surface of each shell. He further found that the larger vertical canals, before reaching the surface, became enlarged and gave off each a crown of smaller canals also terminating at the surface in cup-shaped apertures, and that the canals and apertures, small and large, are distributed evenly over the outer surface of the shell. He decalcified the shells, and found in the canal system ramifications of soft tissue, which he recognized as offsets of the mantle, and considered homologous with those of Balanidæ and Brachiopods. He erroneously regarded the soft tissue ramifications as tubular and respiratory in function. In 1882 Van Bemmelen, following up his researches, examined the structure of the soft tissues contained in the shell of *Chiton marginatus*, and discovered that the tegmentum is entirely filled with papilliform bodies, which terminate the branches of the network and occupy the surface perforations described by Marshall. He figures and describes the structure of these papillæ and their relations to the tegmentum, and propounds certain theories as to their homologies which will be referred to."

The really important discovery as to the nature of these organs was made by Prof. Mosely himself. In examining a specimen of *Chiton (Schizochiton) incisus*, Sowerby, he was struck with the resemblance of the minute dots already mentioned to eyes, and further examination proved that such was really their nature.

On searching for eyes on the shells of other Chitonidæ, he found them present in the majority of the genera, differing however in each genus more or less in structure and arrangement. Mr. Mosely announced his discovery in the "Annals and Magazine of Natural History" for August, 1884 (Vol. xiv., 5th Series, p. 141). The following is an abbreviated account of these wonderful organs:—

They are circular or oval in outline, varying in measurement from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in diameter, according to the sub-genus or species. They appear under reflected light as convex, circular, raised dots of highly refracting transparent matter, surrounded by a narrow zone of pigment, or the margin of the choroid seen

through shell substance. In the centre is a small dark circular spot with a brilliant speck of light reflected by the lens.

It is better to explain on the threshold of these observations, a difficulty which will occur to most persons not very intimately acquainted with the subject, as to how these eyes on the outside of the shell could communicate their impressions to the nerve centres of the animal. This difficulty will be met most easily in the words of Mr. Mosely, remarking at the same time that the shell, no matter how hard or apparently independent of the animal, is a structure intimately associated with the integument, and is always permeated more or less by nerve-channels between the different plates of shelly matter. Now in the case of the Chitons, this is the more easily understood from their peculiar structure. They were formerly termed multivalve shells; because they are covered with eight moveable plates of shelly matter, sustained in their places by a cartilaginous frame which is a horny extension of the mantle. The imbedded portion of each plate is produced into two processes belonging to the lowest plate of shelly matter. The exposed portion is very much thickened, of a rugose sculpture and colored, forming a kind of raised, triangular, winged area at each side. This is called the tegmentum, and at the junction of these two plates of shell are the openings through which the nerve branches are given off to form the optic nerves as described hereafter. I may mention, that though Mr. Mosely regards this structure as peculiar to the Chitonidæ, something similar to it exists amongst a very large number of Mollusca, both univalves and bivalves, as far as my observation goes; though of course modified according to the peculiar structure of each. It is more apparent in the case of Chitons, but it is hard to understand in many cases how the juncture is effected, yet I think I shall be able to show how the result is attained in those species in which I have found eyes. I now give the result of Prof. Mosely's examination.

"The entire substance of the tegmentum in the Chitonidæ, is traversed by a series of branching canals, which are occupied, in the living condition of the animal, by corresponding ramifications of soft tissues, accompanied by abundance of nerves. The nerves and strands of other soft tissue enter the substance of the tegmentum along the line of junction of its margin with the upper surface of the articulamentum. A narrow area, perforated all over by pores, so as to have a sieve-like appearance, here intervenes between the two components of the shells, and in some shells the actual margin of the tegmentum itself is perforated. In the case of the intermediate shells, in most genera there are a pair of slits (*incisuræ laterales*), one on either side, in the lateral lamina of insertion; these slits lead to two narrow tracts in the deeper

substance of the shell, which follow the line of separation between the *area centralis* and the *areae laterales* of the tegmentum. These narrow tracts are permeated by numerous longitudinal canals, which lodge each a specially large stem of soft tissue and nerves, which ramifies in the substance of the tegmentum. Corresponding with this tract, on the under surface of the shell, are a series of minute openings leading into it, through which further strands of soft tissue, possibly mostly nervous, pass from the surface of the shell-bed into the shell, to give the general network of soft tissue. In the anterior and posterior shells there are usually a considerable number of such marginal slits, each with a corresponding tubular tract and ramifying strands of soft tissues.

The network of soft tissues contained in the canals within the tegmentum ramifies towards the shell-surface and terminates there either in eyes or in peculiar elongate bodies, which, apparently, are organs of touch. These latter are long, somewhat sausage-shaped bodies, which terminate at their free extremity in dice-box shaped plugs of transparent tissue, which show a somewhat complicated structure. The tegmenta of the shells of most Chitonidæ are perforated at the surface by circular apertures or pores of two sizes, arranged in more or less definite patterns with regard to one another, and sometimes with regard to the eyes also. The end plugs of the sense-organs above described, lie in these larger pores. From the sides of the sausage-shaped sense-organs are given off more or less numerous fine strings of soft tissue which, diverging, pass to the smaller pores above described, and there terminate in very small plugs, just like those of the larger similar organs, but less complex in structure."

Having disposed of the difficulties with regard to the Chitonidæ, he explains the manner in which the soft structures of each eye are located. They lie in a somewhat pear-shaped chamber in the substance of the tegmentum or exposed area of the shell. The portion which would correspond with the stalk of the pear is the canal for the optic nerve, directed towards the free margin of the tegmentum, whence the nerve reaches it. One side of the chamber is pierced by a circular aperture which is covered by a calcareous cornea. This cornea is formed of concentric lamellæ, and its substance is continuous at its margins with the shelly tegmentum. The eye-cavity is lined with a dark brown pigment membrane which projects slightly round the margin of the aperture and forms an iris. There is a perfectly transparent hyaline, strongly bi-convex lens composed of soft tissue and of fibrous structure. It dissolves slowly in strong acetic acid. The optic nerve does not perforate the retina, which is composed of a single layer of very short rods with their ends directed towards the light. Some of the fibres of the optic nerve, without proceeding to the retina, pass round

outside, perforating the choroid, and end at the surface of the shell, or round the cornea, apparently forming a sensitive zone round each eye.

Mr. Mosely was not successful in finding these eyes in all the genera of the family. They were entirely absent from the genus *Chiton* and some others. In that genus the perforations and sense-organs were present, but no eyes. In *Chiton (Corephium) aculeatus*, L., the eyes were present in enormous numbers. He reckoned there must be 8,500 eyes. This is an Australian species. In *Chiton (Tonicia) marmoratus*, Gmel., the eyes are sunk in little pit-like depressions on the shell-surface. He searched in vain also for any similar eyes in the shells of *Patella* and other allied genera. He regarded the shells of the Chitonidæ as possessing a feature peculiar of its kind, entirely unrepresented in other Mollusca.

It need hardly be said that so important and interesting a discovery made quite a sensation amongst naturalists, and the wonder was that such numerous organs should so long have awaited discovery. So important was it deemed that at the British Museum at South Kensington, in the portion devoted to marine conchology, the Chitons were brought into prominence for the benefit of visitors. One of the shells is conspicuously labelled for exhibition, and an enlarged model is placed by the side, showing the eyes on the surface of the shell, the prominent rounded tubercles on the tegmentum beside them, and minute protuberances for pores containing nerves of sense.

Before dealing in detail with what instances Australia furnishes of this remarkable character, a few preliminary remarks must be made. One of the shells on which Prof. Mosely made his most important observations was an Australian *Chiton*, that is *Chiton (Corephium) aculeatus*, which is very common in Sydney Harbour. It is probable that the other genera amongst which he searched in vain for shell-eyes were European species, and possibly the shells were not preserved in spirit, in which case the eyes would be difficult to discover. One further observation has to be made.

It has already been remarked that these shells are nacreous. In the case of *Patella tramoserica*, Martyn, which is the species with which we have been dealing previously, it will be remarked when looking at the shell from the inside that there is a narrow margin at the extreme edge, passing all round the nacreous inner line. This is where the outside plate or tegmentum overlaps the internal or nacreous lining. A similar structure is seen on a very great number of shells, whether they are nacreous or not, and I call attention to it here as an illustration of the conspicuous way in which the double-plated structure is universal amongst the

shell-bearing Mollusca. It is not here, however, that the nerves for the organs of sense communicate between the shell and the softer tissues. If we examine the cup-shaped interior of the simple conical shell of *Patella* we shall find a horse-shoe shaped depression in the interior lining. In this there are special perforations for the passage of nerve-fibres and vessels of circulation. In all the univalve Mollusca there are muscular attachments which perform the same office of fixing the shell in its habitation, and where a communication is established between the hard and soft structures. It is obvious that the passage for the nerves, etc., could not be looked for at the periphery or peristome of the shell, where the tegmentum overlaps; because, though the mantle usually stretches down to it and continues adding to its structure, it can be withdrawn far within the shell when occasion requires it. But the overlapping is important as showing in every case the existence of the tegmentum and the inner plate, as much in every family as amongst the Chitonidæ. In *Patella* the overlapping plate forms a conspicuous, though very narrow margin. In some species of *Acmea* it is wide, and of a different colour from the tegmentum; that is to say, sometimes when the latter is variegated the overlapping margin has a uniform band of colour or *vice versa*. In *Trochocochea* there are three coats: the tegmentum, the nacre, and a white shelly coat forming an inner lip round the mouth, of broad, dark brown bands and narrow green ones. In *Siphonaria denticulata*, Quoy, it is an extremely narrow margin, not at all easy to see, and sometimes itself overlapped by the broken and split edges of the periostraca. Other conical shells need not be particularized.

In *Risella melanostoma*, Gmel., this margin is not very difficult to see as a light-coloured, narrow band round the external lip and so on to the base of the columella. But the line of junction between the different plates requires a hand-lens to make out. In all of our Australian species of *Littorina* it forms a conspicuous addition to the ornamentation of the mouth of the shell. Of all the Trochidæ the same may be said.

This digression has such an important bearing on the subject matter of these eyes, that I must be pardoned inserting it here for the sake of non-scientific readers, and with a view to certain inferences which I shall have to lay stress upon hereafter. But the important point which has to be here insisted upon is that there are in all shells two plates, between which are nerve-fibres, and as I shall show afterwards, in which are nerve centres.

As far as my observations have gone, I have come to the conclusion that the shell-eyes are by no means confined to the Chitonidæ, and that in fact a multiplicity of eyes of this kind is

the rule rather than the exception amongst the Mollusca. It is now many years since I first noticed the peculiar ornamentation with which some of our coast shells are varied ; more particularly in the radiating lines and papillæ or warts, with which the surface is adorned. This is more conspicuous amongst the bivalves, and I was often struck, when examining them with a lens, at observing the peculiar crystalline clearness of some of these asperities upon their summits. In *Anatina tasmanica*, Reeve, to which further reference will be made, this is especially conspicuous. The whole exterior surface of the shell is rough with little dots, not symmetrically placed, nor uniform in size, though small and sometimes aggregated together in little clusters. But what struck me most about these little marks was, that when I examined them with a lens, I found that each had a little transparent crystalline summit which brightly reflected the light. But almost any shell in its natural state, if carefully examined, I had noticed, had something of the same kind upon its surface. Usually this was so small, that a rather powerful hand-lens was required for its detection. Keeping to the example that I have used all through this paper, I may mention the limpets. In a good shell that had not been much eroded, my attention was early called to certain little marks and dots upon the upper surface which must, I felt convinced have had some meaning. As a rule they appear like little stained pits and depressions, but sometimes forming raised clusters of crystalline projections which correspond with the ornaments on the shell. It never occurred to me to suggest that they were eyes, but I felt convinced they had a purpose, and that an important one, in the economy of the shell. I was equally interested with the glassy hemispherical projections on the calcareous opercula of many shells, especially *Nerita* and the trochiform and turbinatè Gastropods. The latter still remain a partially unsolved problem to me. One circumstance that served me as a clue, was in the case of *Lima multicostata*, Sowerby, a bivalve, the hooded imbrications on which make a beautifully ornamented shell, covered with sharp asperities. Each of the little hooded scales I observed, had one or a cluster of the small crystalline nodules within it, often at the summit, and I could not help remarking years ago, that it looked to me like a bull's-eye lens placed in a reflector, in a most advantageous position to give light to the animal. Furthermore, even the smooth univalve shells were observed to have a very minute ornamentation of this kind in the fine striæ which follow the spiral windings of the whorls ; but I did not pursue the subject further, though convinced that such a uniform ornament must have a meaning. Structures with no higher purpose than mere ornament are unknown in nature, and perhaps the tendencies of the doctrines of evolution incline us

too readily to forego searching for a purpose in insignificant details. Though this may appear to many a very antiquated idea, in practice it encourages one to attempt the solution of many an interesting problem.

I shared the interest and wonder of the public at the discovery made by the great naturalist of the Challenger, and I immediately resorted to the old observations made on Australian shells, particularly *Patella*, *Anatina*, *Lima*, *Trigonia*, and the littoral shells generally. No time was lost in making investigations, though no success was expected with *Patella*, as Mr. Mosely had looked in vain for the small eyes amongst some species of this genus. With some shells, I was not successful, and, as often is the case, these being the first tried led to discouragement and almost an abandonment of the search. But remembering the more conspicuous instances amongst the genera above mentioned, I renewed the investigation, and was rewarded with the discovery of organs, which I have no doubt whatever, are similar to those described by Prof. Mosely. I am fully aware, however, that what might satisfy me in a matter of the kind will require something more to meet all the objections which may be felt by other observers, and therefore beg to record the discovery, if such it be, with some little diffidence, knowing the deficiencies under which I laboured for want of technical apparatus, and also of experience in the higher paths of microscopical examinations. However, I shall give the public the fullest opportunity of verifying or disproving my conclusions by every detail about my methods and the supposed facts observed. It is to be hoped after this there will not be much error involved. In any case, I feel confident that as the examples quoted are of easy access, my conclusions will be speedily confirmed or otherwise.

Briefly, therefore, I may now state that I have found on a large number of shells, eyes of the kind described by Prof. Mosely; that is, associated with sense-organs and supplied with nerve channels of a similar kind. These eyes have been observed in various forms, on so large a proportionate number of shells, that I am inclined to regard their absence as rather the exception, but as in matters of detail there is considerable difference in the mode in which the eyes occur, their number and position, it is necessary to arrange a classified list of these organs.

Eyes and sense-organs in the Mollusca may be divided into four kinds, that is:—1 Minute organs in great numbers on the outer surface or tegmentum of the shell of both bivalves and univalves. 2. Large and solitary eyes in the shell-substance or on the horny tissues, in size and in special peculiarities to be afterwards described, like the tentacular eyes. 3. Eyes on the mantle-lobes of both bivalves and univalves, generally on stalked pedicels, but

sometimes on the surface of the mantle, or immersed to some extent in its tissue. 4. Eyes and sense-organs on the opercula, generally stalked or on raised tubercles. A short description of each of these kinds is necessary before describing particular instances.

SHELL EYES OF THE TEGMENTUM.—If a section be made of any of the following common littoral shells of Australia, certain appearances, to be mentioned presently, will be noticed. The species I now particularly refer to are *Patella tramoserica*, Martyn, *Acmæa septiformis*, Q. & G., *Siphonaria diemenensis*, Q. & G., *Cerithium ebeninum*, Brug., *Turbo (Senectus) gruneri*, Philippi, *T. (Lunella) undulatus*, Chem., *Malleus vulgaris*, Lam., (the hammer-headed oyster), *Mercenaria paucilamellata*, Dunker, *Trigonia lamarckii*, Gray, *T. margaritacea*, Lamarck, *Anatina tasmanica*, Reeve, *Ostrea mordax*, Gould, and *Arca trapezia*, Desh. It will be observed that I do not select these species as being exceptional or extraordinary illustrations (except in the genus *Trigonia*). They are in truth taken indiscriminately from the many shells which I have examined, only I happen to have these specimens before me while I am writing the present remarks. A section through any of these shells shows on the outer surface a thin stratum of partly refractive structure. Under the microscope this layer is seen to consist of transparent capsules with a hyaline covering outwardly, and frequently a distinct lens and pupil within. These capsules are supplied with nerves from below, from a large nerve-ganglion in the shell in the case of the bivalves, and from a spirally shaped trunk in the columella, in the case of univalves. All the capsules cannot be regarded as visual organs, or at any rate they are too minute to ascertain this satisfactorily; but they are all supplied with nerves abundantly. For the most part they are so close together as to form a pavement, but occasionally they are scattered. This layer has been of course observed by every naturalist, and has generally been confounded with the fibrous layer of prismatic shell-structure, but that it subserves a far more interesting and important purpose I think I shall be able to show.

If instead of taking a transverse section, a portion of the shell is ground flat and thin from below, the eyes can be seen and the sense-organs (through the shell) with great distinctness, sometimes with the aid of a lens, but sometimes requiring to be magnified considerably. They occur in the form of minute pellucid, raised, circular, or oval points, transparent, refracting the light brightly and with a minute dark dot in the centre. They are so thickly scattered over the shell-surface as in some cases to leave scarcely a point which is without them. In some others they are sunk in little pits and depressions, or in the valleys between the rugæ of

the surface. Their position is commonly arranged so as to give vision at every angle to the animal. Of course the majority of the eyes upon the shell-surface could only look upwards if they have no power of movement, about which nothing can be asserted as yet. But I find that every little point or elevation is chosen as a location for an eye or a cluster of eyes, and thus there is a close connection between the surface form and these organs of vision. On the ribs of shells it will often be observed that there are raised nodules, points, or bosses at regular intervals, gradually increasing in size in a radiate manner from the summit to the periphery. Such ornaments, which often form the special beauty of a shell, reminding one of the crockets on spires in Architecture, are lit up by these crystalline optical arrangements, making a shell in which they are well preserved look like a city adorned with rows of street-lamps, especially when the surface is wetted or oiled. The eyes are nearly always so minute as to be only visible with the microscope. When the number and variety of them is considered, some will wonder that they have not been noticed before, but they are seldom preserved on the surface of shells in museums and collections. The scrubbing, washing, decalcifying, and polishing to which they have been subjected has long ago swept away these fragile little crystals. My opinion also is that the animal tissues connected with these visual organs are of a very perishable nature, and that their places are only indicated by pits after a little dessication. The calcareous matter contained in the cornea soon ceases to reflect light, and becomes white and opaque. In very old shells the former presence of these eyes is indicated by innumerable pits, as close as small-pox markings on the human face. In this manner it is not impossible that they may be detected in fossil species.

I have found these visual organs as common amongst the bivalves as amongst the univalves. In some genera they are present in extraordinary numbers. This I regard as specially the case with *Trigonia lamarckii*, already referred to. I have, moreover, good reason for the opinion that such eyes are still to be found amongst shells whose upper plates or tegmenta are formed of fine lamellæ, such as the common oyster.

ISOLATED EYES.—Besides these tegmentary eyes, solitary eyes of larger size are found on the edge of the shell, on the operculum and on the periostraca when it is horny. There are peculiarities about these organs which show them to be quite different from the tegmentary visual organs. (1) They are of much larger size; (2) they occur solitary, in pairs, triplets, or even little clusters; (3) they are irregularly spherical or oval, of dark colour, and highly refractive in the centre; (4) they are probably of the vertebrate type, that is to say the nerve penetrates through

the rods and spreads out on the inner surface, and the rods themselves are reversed; (5) there are special peculiarities in the manner in which the nerves supply these organs, an illustration of which can be seen at pl. vi., fig. 8, which is an eye found in the substance of the shell of *Patella tramoserica* while being ground down for a section. It need not appear improbable that such eyes should become entombed and disused, for an instance is met in the case of *Trigonia margaritacea*, where it will be shown that large eyes like those found in the Chitonidæ exist abundantly on the interior lining of the shell. This instance will be referred to subsequently.

MANTLE EYES.—Organs similar to those described in the cases of *Pecten maximus*, Lam., *P. jacobæus*, Lam., and *P. opercularis*, Lam., have been observed in a few bivalves, and probably will be found more numerous. It must not be supposed, however, that every warty excrescence on the mantle is necessarily an eye. Any one who has visited a coral reef in the Southern Hemisphere cannot fail to have been attracted by the beautiful appearance of the clams. As the tide recedes the open valves display most beautiful colours, especially in fringes and dots of the brightest blue and green. These are species of *Tridacna* and *Hippopus*. It may not be taken for granted that these dots are eyes, as Brock has shown that they are warts and flask-like cysts, probably containing chlorophyll (see J. Brock, *Über die sogenannten Augen von Tridacna, &c.*)* I do not, however, think that this settles the question as to all the coloured warts which are displayed upon the coral reefs, by species of *Hippopus* as well as *Tridacna*. It should be a special enquiry with naturalists in collecting in these localities as to the true nature of these organs. They are so large and the species are so abundant that they should afford an easy, as well as interesting field of research.

Associated with such mantle-warts are certain patches of pigment cells which are found at regular intervals on the edge of the mantle as already described. Under the microscope this pigment has usually associated with it minute, highly refractive, spherical cells, much larger than the refractive bodies associated with nerve tissue, and in fact hardly mistakable for anything else than lenses. Under the lens there is a cylindrical prolongation forming a capsule not unlike the membrane forming the prismatic structure in the substance of the shell. I shall mention hereafter an instance of this in the case of a young specimen of *Siphonaria diemenensis* where 80 to 90 of such visual or sense organs were observed upon a portion of the mantle in front of the head.

* Zeitschrift für Wissenschaftliche Zoologie. Sechshundvierzigster Band. Leipzig, 1888, p. 280. A translation of this paper appeared in the *Ann- and Mag. Nat. Hist.*, June, 1888, p. 435.

As far as my observations go these eyes are somewhat like the dorsal eyes of *Onchidium*, and not of the vertebrate type; that is to say the nerve is not spread out on the inner surface of the retina and the rods or cones are not reversed. I take this opportunity of saying that I do not consider the negative conclusions of any observer as decisive as to the character of the organs to which I am referring on the mantle. I have known many able and experienced histologists, possibly from an excess of caution, unable to find eyes in the mantle of *Onchidium*, and this certainly not for want of any manipulative skill in preparing the sections.

Amongst the *Annulata* we find something very similar to what I have described above. Eyes are placed in large numbers on certain organs in their young stage and subsequently change their position. Among the *Chaetopoda*, the eyes which are present in the larva, and even in later stages, disappear or are represented by mere pigment-spots.

OPERCULUM EYES.—The character of these eyes depends upon whether the opercula are calcareous or chitinous. In the former case small glassy tubercles, pedicels or bosses stud the surface of the operculum. The manner in which these occur is so varied that separate details will be required for each species. As a type I may take the genus *Nerita*, the shell of which and the columella are studded with small, oblong, transparent bosses or rounded tubercles. Under the microscope these are found to be penetrated by smaller sense-organs, but there are solitary eyes as well either on raised calcareous pedestals or spherical, sessile eyes. These are also found on the chitinous opercula associated with minute spherical highly refractive bodies, which are like eyes, but hitherto have not satisfactorily shown the minute interior structure which has been detected in other visual organs.

However extraordinary these sense-organs, with a double office may seem, we are familiar with such a state of things amongst the *Annulata*. The abundance of eyes with which the *Platyhelminthes* are furnished, agree in so remarkable a manner with the structure of the organs of feeling, that a condition appears to exist in which specific sensory organs are evolved from mere organs of sensation found in the integument. (See Gegenbaur, Comp. Anat. Vermes Sect. 125.)*

* "Non-zoological readers, when dealing with the genera of the lower sub-kingdoms, must put aside the ideas formed by visual organs of the ordinary type, as the animals have eyes both in number and variety of structure widely departing from the usual acceptance of the term. The following quotation from Gegenbaur in treating of the visual organs of *Vermes* will show what extraordinary variations we may expect to meet with. Speaking of the way in which the nerves are pressed together

With regard to the land and freshwater shells, observations have still to be made, though I incline to the opinion that these will be found to furnish instances such as I have described. In the case of shells covered with periostraca, the land shells especially, and such species as *Triton spengleri*, I have not been able to find these visual organs, and this is also the case with some species of *Chiton*. I do not find that the Chitonidæ are more bountifully provided with eyes than other genera, in fact they are less so, and as for *Onchidium*, the genus in which these wonderful sense-organs were first discovered, the eyes in all the species are proportionately very few. We cannot moreover be sure from the absence of eyes in one particular case, that such a peculiarity is specific, because in some species of *Onchidium* I have found no eyes in one individual of a species and the full complement in another. The greatest number of eyes in any one valve of a shell is in the case of *Trigonia lamarckii*, as far as my observations go, and in this case I think there must be about 12,000 in each valve of an adult specimen.

Those shells which have a smooth or enamelled tegmentum are those in which the eyes are the least numerous, and I would venture to suggest that this may be made up by some special arrangement in the soft tissues of the animal. Thus in *Cypræa* and the cowries generally, all who have seen the living animal will remember the number of papillæ of extraordinary shape with which the inner surface of the mantle is studded. These may possibly be sense organs or something to make up for the optical arrangements which are most probably absent from the shell.

Before entering into any detail about the sense-organs in different species, I may sum up briefly by saying that the presence

into a concave layer, he says: "Influential in the development of this arrangement is the multiplication of the perceptive elements, and the formation of refracting media. Just as the eyes are completely wanting in the majority of the Scoleina which live in the dark, so also these organs undergo degeneration in the Tubicola among the Chætopoda. The eyes which are present in the larvæ and even in later stages, disappear, or are represented by mere pigment-spots, when they enter on the fixed mode of life. The development of the visual organs on the branchial tufts of the head is an adaption of another kind, which is seen in certain Sabellidæ (Branchiomma); in them the eyes are either placed in large numbers on the pinnate branches of the branchial filaments, or at their ends only. In other Annelides there is a similar change of position as compared with the primitive one. In many there are eyes at the posterior end of the body, as well as on the cephalic segment; and finally in the genus *Polyopthalmus* there is a pair of eyes on each metamere, in addition to those on the head. We here find an arrangement which is not only of importance as bearing on the estimation of the metameres, but is also a proof that visual organs may be developed at points which in other forms only carry sensory organs of a lower kind."

of minute eyes in the shells in immense numbers is a characteristic of many Mollusca. Like every other arrangement of this kind in nature, it is subject to much variation. It is abundantly present or nearly absent, it is larger or smaller, prominent or inconspicuous in different groups. There is sometimes a geographical association of certain forms of these organs, dependent upon the conditions of life being the same, such as the climate, temperature, food, and so forth.

The Siphonostomata have not been subjected to such examination as the plant-feeding littoral shells; but the Tritonidæ and Buccinidæ have furnished abundant instances, amongst which I may name *Triton spengleri*. Lam., *Buccinum alveolatum*, Kiener, and *Polytropha margine-alba*, Fisch., of the family of Purpuridæ. In most of the above-mentioned families the lines of growth are represented by fine imbrications of shelly matter, often forming varices on the spiral ribs. At the junction of the shelly imbrications with these ribs, there are generally sense-organs, which follow one another in regular progression to the mouth of the shell.

In giving illustrations of the way in which these sense-organs occur, a few species only can be dealt with, because the discovery is too recent to have allowed time for minute dissection in a great many cases. I must confine myself to these few, and will continue with the simple, conical, littoral shell with which this Essay was commenced, namely, *Patella tramoserica*.

We find, generally, that a very uniform system of colour prevails amongst the limpets. Radiating lines of brown and yellow spots and angular markings occur very commonly. Beautiful lines of rich deep brown, golden yellow and orange are common among a good many species. What purposes they subserve cannot be said; but that they do belong to some very important economy we may be convinced, for there are certain coloured dots on the edges of the mantle which correspond with the dark coloured rays on the shell. It has occurred to me that perhaps these bands of colour in the shell may serve as pigment-coats for some of the eyes in the shell; though it would be difficult to explain in that case why they should be absent from places where the organs are just as numerous. A little further explanation about the anatomy of the species of limpet with which we are dealing will serve to clear up some matters connected with the eyes or other sense-organs.

I find that in this species of *Patella*, the mantle stretches down to the margin of the upper plate already spoken of. I distinguish three folds of tissue: namely—the shell or testaceous fold which lies next to the shell, the tentacle-bearing or median fold and the branchial fold. All these extend between the foot and the shell, excepting for a space round the head, where the branchial fold

ceases. The outer side of the testaceous fold has a narrow margin like a hem, consisting of two parallel lines of dark pigment, with clouds and dots of the same material between them, extending all round the membrane. On its inner side it has short lines and dots of brownish pigment which correspond with remarkable exactness to the lines of colour on the shell. These dots when examined under the microscope, are seen to be full of small and highly refractive cells. The tentacular fold bears a series of small tentacles, forming a fringe all round the mantle. These tentacular filaments extend slightly beyond the edge of the mantle; they are transparent, but more or less coloured with transverse lines of deep olive or blackish pigment. There are from 90 to 100 of such tentacles in an adult shell. They are quite distinct from the branchial fringe which lies further within the cavity, leaving a small space, between the gills and the muscular attachments of the foot. With the exception of the narrow pigmented margin on the edge of the mantle there is no pigment of a dark colour, except on these tentacles; but the origin of some of them is marked for a considerable distance with a yellowish line, and the space between the ophthalmic fold and the testaceous fold has a slight tinge of yellow, deeper or as deep in tint as the gills. The tentacles are solitary; I have not met with double ones; but some of them have, half way from the tip, a little bulb like the eye-bearing bulb on the tentacles of most of the Mollusca. A great many of these tentacles are quite transparent, of a pale greenish-yellow, and showing no trace of structure except with very high magnifying powers. Some of them, perhaps more than half, have spots and rings of very dark olive or black pigment-cells. Those tentacles on which there is something like an eye-bearing bulb do not, as far as I have seen, show any traces of a lens, or anything indeed but a small amount of pigment, generally disposed in rings round the base of the bulb.

But what I have observed is occasionally small bulbs surrounded with pigment, lying between the tentacular fold and the testaceous fold, which had the shape and appearance of eyes, except that what would correspond with the cornea seemed to be opaque. I hardly wish to assert that they are visual organs, though they may have that function and at any rate deserve further examination.

The inner surface of the mantle is slightly wrinkled, but is capable of great extension to the very outward edge of the shell, and of being drawn in, in curtained lobes, within the margin of the foot. Frequently the tentacular fold is withdrawn between the branchial and testaceous folds, so that the rounded bulbs above described become completely covered, or project in a more eye-like fashion.

To return now to the shell of which an enlarged figure is given at pl. 1, fig. 1, magnified about eight or ten diameters. In this plate it should be remarked the full ornamentation of the shell is not given, but only a sketch of the general design and detail of two ribs. It is supposed also that the shell has all its ornamentation in full detail, which I may state is a thing that is seldom or never met in nature. The smaller ribs are always more or less irregular, and sometimes the larger ones are, so to speak, aborted, as if it were undecided whether they were intended to be large or small. The nodules on the smaller ribs are often raised, scale-like imbrications, but this as well as the colouring is inconstant. The plate represents an ideal shell of a species which, like every other in nature, is subject to great variations. The apex is anterior, and from it proceed in a radiate manner about 40 or sometimes as many as 50 conical ribs; sometimes, but not always, large and small alternated. These ribs are interrupted at intervals with somewhat inconspicuous lines of growth. The whole shell is clouded and stained with lines and blotches of colour as already mentioned. These lines are not confined to the ribs or to the depressions between them; though sometimes they very conspicuously form double lines at intervals on the smaller intercalated ribs at each side of most larger ribs. There is generally a line of colour on the testaceous fold of the mantle corresponding with the lines of colour on the shell. I have already referred to the possible connection between pigment-coats and these testaceous markings. There is a very thin chitinous periostraca on all the shells, which serves effectually to conceal the minor details of the shell-surface. If, however, it is moistened with spirit or clove oil, a wonderful sight will be presented to a good and powerful hand-lens. A number of minute points shining with intense brilliancy are scattered irregularly and somewhat numerous over the whole shell-surface. No particular symmetry can be detected as yet, and even it may require some little experience to perceive them at all.

The sight presented is a very marvellous one, and forcibly recalls the brilliant points of light sparkling out of the darkness in the field of a telescope directed to the heavens at night. One realizes the truth of the saying that what the telescope is to the astronomer, the microscope is to the naturalist. Possibly there is not so much awe and mystery connected with these little diamonds so brilliantly reflecting into the tube of the microscope, for we know that with the aid of this instrument we can resolve the whole structure of even the most minute in a manner we are yet far from being able to do with the stars.

In order to see the full extent and beauty of the arrangement of the eyes on the shell, a little manipulation is necessary. It

should be allowed to macerate in a weak solution of acid: two per cent of nitric acid will be sufficient. The time required for the maceration depends upon the condition of the shell. Shells that are not corroded must be selected, and in spite of the numbers of the species on the rocks, uncorroded specimens are not so common as one might expect. For good, clean specimens of adult shells 48 hours maceration I have usually found sufficient. On removal from the pickle the shell can be lightly brushed with a not too hard brush. On examination now the shell will be found to present quite a different aspect. Along each rib will be seen a beautiful series of tubercles for sense-organs, each of the larger eyes occupying the slight ridge made on the rib by the fine concentric lines of growth. There are regular rows also of larger eyes on the depressions between the ribs. Thus the appearance becomes one of much beauty. A series of shining gems radiating in gradually increasing size, studs the surface of the shell, making it quite dazzling. It is very difficult to convey any idea of the effect of the whole without seeming to exaggerate. As far as my experience goes I have seen nothing at all comparable with it, after years spent in the observation of nature.

Let us now consider a little closely the character of these eyes. Though appearing like a row of shining gems increasing slightly in magnitude from the apex of the shell to the margin, they are not always simple eyes. Sometimes the light will be found to proceed from two eyes of small size placed close together, and sometimes a pair of eyes so closely united that they seem almost like a large oblong one. Sometimes they are a cluster of very minute eyes, as many as five or six, or perhaps more, being found associated together. Though as a rule they occur in rows, this is not without exceptions. Smaller eyes are scattered on the sides of the ribs. I believe they are nearly always smaller when occurring irregularly in this manner. I have chosen this species as a typical one, and as affording with the least trouble an illustration of what I must be excused for calling one of the great wonders of nature. But it must not be supposed that the instance is exceptional; there are many other shells that might have been chosen as examples.

The question will naturally occur to most persons as to how these structures are known to be eyes, and it would be almost sufficient to answer that they are, in position, in character, and as far as one can judge, in construction, the same organs which have been so intimately examined and figured by Prof. Mosely. In the "Quarterly Journal of Microscopical Science" for January, 1885, there are furnished by the above named Professor, elaborate drawings of such eyes from sections. From these it is plainly seen that there are all the characteristics of an eye, and an eye in

no way less elaborate than that which is used for the purposes of vision amongst other animals. A vertical section through the tegmentum and the centre of one of the eyes, shows structures in the following order :—1. A calcareous cornea. 2. An iris. 3. A lens. 4. A retina, with rods, to the inner surface of which are attached the optic nerves. The most of these tissues or organs are included within a pigmented capsule, the opening of which exteriorly forms the iris. As far, therefore, as his observations on the Chitonidæ extended, the eyes are most complete and elaborate. No doubt further observations are necessary, and will not be long in forthcoming, but what we have is amply sufficient to prove that nothing is wanting to these organs to entitle them to be regarded as eyes of the most complete kind.

Now, though I am unable to furnish sections of so complete and satisfactory a kind as those given by the Linacre Professor of Anatomy, not having either the technical skill or the technical apparatus for the purpose; yet still I have been able to satisfy myself that I have been dealing with the same organs in many Australian shells which he has found in the Chitonidæ. I find first of all that these little glassy structures, when examined with higher powers under the microscope, show the curtain of pigment-cells in the centre forming a ring which we call an iris, though probably it may not be the homologue of what is usually understood by that term. Furthermore in *Patella tramoserica*, within the small crystalline capsule, there is a lens and a retina, with a layer of rods or cells containing the ultimate fibrils of nervous tissue. Behind this the strands of the optic nerve spread out, so that the eyes are not of the vertebrate type, but of the form usual amongst Mollusca. At the base of the capsules, directed somewhat obliquely into the substance of the tegmentum, is a nerve-channel, which appears in the form of an extremely delicate tube or sheath. These sheaths are so closely associated together that they give a fibrous appearance to the stratum in which they occur, and their oblique direction is crossed at right angles by other fibres. Or again this stratum of nerve-fibres has them arranged at almost every angle, so that they give a hackled appearance to the stratum. The fibres terminate at a horizontal line of division which separates the crowded nerve-fibres from the nacreous layer. In this is a mass of nervous tissue which I shall distinguish as Neurospongium.* I find it forming large ganglia connected with the eyes and sense-organs in many shells.

* This term has been proposed by Mr. Sydney Hickson in his paper on the "Optic Tract of Insects." (Quarterly Journal of Microscopical Science, Vol. xxv., p. 219.) He says "The opticon itself consists of a very fine granular matrix, traversed throughout by a fine mesh-work of

It must not be supposed that this analysis of the oblique fibrous layer is applicable as a description of every shell. Let it be understood that I am simply describing now what is observed in one particular species, that is *Patella tramoserica*. I should further state also in reference to this species that the membranaceous nerve-channels to which I have referred are silky and opalescent, of bluish-white or golden colour, and to this the tint of the nacre is owing. A similar structure in other shells has always been identified with the prismatic shell-structures, and it may have been in this case, but I claim for it the interpretation which I here describe.

Besides the eyes on the tegmentum, I have been able to obtain occasional sections of visual organs of another kind on the same species. As these were of larger size they gave greater facilities for examination.

At pl. vi., fig. 8, there is an illustration showing an eye which was revealed in making a section through the substance of the shell of *Patella tramoserica*. It had formerly been on the edge of the periostraca, but had been covered up by the growth of the shell. It was a larger eye than any seen on the shell-surface. It will be seen that the structure is of the type common to the eyes of Invertebrata generally, and different from those which have been described by Dr. Semper as occurring in the dorsal mantle of *Onchidium*. The eyes receive the optic nerve at the base of the rods, and it does not pass beyond them. In the Chitonidæ, as described by Prof. Mosely, the optic nerve which supplies the eye gives off from its strands nerve-fibres which pierce through the capsule and come to the surface issuing from the larger or smaller pores. These nerve-fibres are named by the professor, *Macræsthètes* and *Micræsthètes*. Here we have a different arrangement: a small branch of the optic nerve becomes detached before it enters the eye-capsule and makes its way to the outside where it joins on to the pigment-coat near the cornea.

Possibly we have in *Patella micræsthètes* and *macræsthètes* also, and they may emerge to the surface through some of the sheaths described, which probably are not all connected with visual organs. Sometimes it is very difficult to see the passage of the nerve from the membranaceous tube or sheath here

minute fibrillæ, similar to the minute network of primitive fibrillæ described by Gerlach in the mammalian brain and spinal cord. This description of the minute structure of the opticon applies equally to the epi-opticon and principal ganglia of the body. As this tissue is very commonly met with in the animal kingdom, and has not, as far as I am aware, yet received any separate name, I propose to call it a *neurospongium*. In many insects the *neurospongium* of the opticon is traversed by fibrils, and in some cases it contains a few scattered nerve or even ganglion-cells."

referred to ; but generally it forms a cloud of pigment which soon merges into the highly refractive nerve-substance which forms the ganglion supplying all these sense-organs.

In one section of *Patella* the nerve-fibres form a dark cloud of pigment at the base of the tubes, but swept to one side like smoke from a chimney. In another section there were alternate dark and light bands something like rain-clouds on the edge of the horizon at sea. As a matter of fact, it would be difficult to describe the appearances presented in each individual case without entering endlessly into detail, and therefore I must content myself with saying generally that nerve-fibres can be seen entering or emerging from the tubes which subtend the eye-capsules and diffusing themselves more or less thickly through the substance of the nacreous layer. Here they may be followed until they unite in a darker cloud of nerve-tissue and form a ganglion of what I term neurospongium.

These ganglia in the shell substance are of such peculiar structure that most probably the differences from neurospongium in the opticon of insects will hereafter be found more numerous than the resemblances. It seems as if the substance of the nacreous shell was perforated by innumerable foramina, which concentrate from all directions in one point. These are filled with strands of nerve tissue of the usual character ; but these strands are often marked with pigment which gradually increases in quantity so that the centre of the ganglion is rendered almost dark by it, though it is relieved by the innumerable round refractive bodies such as are usually seen associated with nerve substance. I shall have occasion to speak of these ganglia in the substance of the shell further on. As to the dark pigment, the observations already referred to from Mr. Patten will serve as an explanation.*

At the base of some of the membranous tubes leading up to the micropores, there are certain dark bodies, very much like the pigment cells of eyes. They are round, and they seem constructed to fill up the ends of the tube, and moreover they have a central nucleus or a pupil-like dot. They seem like eyes ; but the question will naturally arise, what purpose could eyes serve thus deep in the substance of the shell ; for they are fully a millimetre or more beneath its surface, which relatively to their size, is a deep burial. Yet as the tube is open they may be deep-seated eyes, and this I am inclined to think is their function.

It should be stated here that in the case of *Patella* and some other shells, the membranous tubes here referred to, even when they have not these deep-seated eyes, bear so strong a resemblance to the cones of an insect's eye, that it is not difficult to suppose

* "The Eyes of Mollusks and Arthropods," *Mittheilungen aus der Zoologischen Station zu Neapel*, Vol. vi., Berlin, 1886, pl. 29, fig. 19.

that this is their true character. What is meant, will be better seen when I am describing the shell-eyes of *Trigonia*; but it may be just mentioned here, that the tubes are cylindrical when they are on a plane surface, but when they radiate from a tubercle, they become conical at the base. If I do not use the word cone, it is because I do not wish to adopt a terminology which would seem to take for granted the supposition that the structures are identical in function. There are, however, so many points of resemblance between the faceted eyes of insects and the shell-eyes in some species that no one need be surprised at finding them classed under the same terminology. On the tubercles of the large Tasmanian *Trigonia*, the cornea of the eyes or sense-organs whichever they may be, becomes detached, and then it is seen so closely to resemble the faceted cornea of an insect's eye, such as the common house-fly, that no one could help identifying one with the other. Moreover there is a very considerable resemblance between the arrangement of the large cerebral ganglia of many insects and the ganglion of the shell. Those who have examined these objects will remember that there is a cerebral ganglion and a ganglion in connection, called the peri-opticon. These various ganglia being separated by comparatively clearer spaces where the nervous fibres decussate, it would be quite easy to point out parts and structures in some shells, *Trigonia* in particular, where a closely similar arrangement exists.

But in addition to the deep-seated eyes just referred to, even in the substance of the shell, we find, as already stated, deep-seated eyes cut off, so to speak, from all communication with the outer world. In the nacre we see fine lines, which represent the former lines of growth in the structure. These have been formerly the edge of the shell, which frequently, as it seems to me have borne eyes. By the growth of the shell this has been covered over with nacreous plates, and the eyes entombed. Thus in more than one place, in the substance of the shell, I have come across eyes which are conspicuous from their large size. A figure of one of them is given at pl. vi., fig. 8, in which the nerve-channels formerly connected with it have entirely disappeared. The eye it will be seen has the structure already described of the Invertebrate type, with the arrangement of the rods reversed. The rods themselves are similar to those observed in the last section of the eye of a limpet just described.

If the nerves have an exit from the plate which forms the inner lining, we might expect to find a channel for their exit similar to that for their entry. And this is what we do find as a matter of fact. There is a small plate of fibrous shelly matter, lining the nacre, and this is densely perforated with membranous tubes which continue through all the fibrous tissue, which here is of the thinnest

possible description, perhaps not more than a third of a millimetre in depth. The surface of the shell itself is crowded with perforations, giving it the cribriform appearance which is familiar to us in the case of the Foraminifera. Small as these perforations are, there seem to be still finer pores between them. The nerve-fibre can often be discerned as it were blocking up the tube. One can easily understand how it is that nacreous shells so easily perish and fall away into powder: they are so perforated and tunnelled that all idea of their solidity is lost, and one wonders how they hold together as they do.

In the case of the mantle-eyes and the dark pigmented matter the evidence is not always so clear. Though a study of the eyes in the mantle of species *Pecten* and *Arca* has shown us beyond doubt that there are optical organs of this kind; yet somewhat similar structures have been found in other species which can only be doubtfully regarded as organs of vision. Thus, for instance, in a European species of oyster, certain pigment balls have been observed beneath the epidermis with tentacles which are nearly pigmentless and ciliated. There is also pigment scattered irregularly over the surface, which in some way subserves the purposes of vision. These cells or similar ones have been found in the European *Patella*. Two kinds of cell have been distinguished; one of which is supposed to be glandular and to secrete the cuticula, while the other is sensitive to light. Similar organs have been found on Mediterranean species of *Pinna* and *Aricula*, which Will described as eyes, and Carrière regarded as glands. The able American anatomist W. Patten, however, found that the organs consisted of an immense number of conical cells expanded at the outer extremity and drawn out to a point at the inner. They were filled with a mass of refracting, closely-packed cells, which gave them the appearance of gland-cells, and were surrounded by narrow ciliated cells, sometimes faintly coloured at their outer ends. Without going into technical detail, which would be difficult to understand without an explanation of terms, the following may be regarded as Mr. Patten's conclusions. The position of these organs on the edge of the mantle and their hemispherical shape resemble closely the faceted eyes of *Arca*; but they have no pigment and the nervation is unknown. But experiments made on *Pinna* and other Mollusks, show that they possess sensitive powers of vision. In the case of *Aricula* the least shadow causes it to close its shell quickly with a force that indicates considerable nervous disturbance.

With reference to these novel and anomalous sense-organs we must not expect that a uniform type will be followed, and this has been so early recognized by observers that a new series of terms has been devised. Instead of distinguishing certain structures by

terms, which implied that they were the homologues of well-known ophthalmic constituents, a perfectly distinct terminology has been resorted to. We have for instance *Ommatidium*, *Retinophora*, *Retinula*, *Retinidium*, *Ommatium*, *Ommerythrine* and *Retineum*. These are the terms suggested by Mr. Patten and others, and as it is necessary to understand them in order to comprehend the literature of the subject and the terms I may be obliged to use, I shall here give their definitions, observing that we are dealing with the highest or ultimate sub-divisions of structure revealed by the microscope.

Ommatidium denotes the structural elements of all eyes, consisting of two to four colourless cells.

Retinophora indicates the aforesaid cells.

Retinula is the circle of pigmented cells surrounding the retinophora.

Retinidium is the specialised part of the *Retia-terminalia* contained in the cuticular secretion of each cell which forms a rod.

Ommatium is a group of ommatidia in which the retinidia are completely isolated, as in the compound eyes of Arthropoda and Mollusks.

Ommerythrine is the red pigment in all eyes; whether confined to the rods alone, or to the retinulæ, or to the underlying tapetum.

Retineum is a collection of ommatidia in which the retinidia of both retinulæ and retinophoræ form a continuous layer; the retinulæ retaining their pigment and primitive arrangement round the retinophora; such as the invaginate eyes of all Mollusks.

It should be added that in many places upon the molluscan hypodermis, especially where exposed to the light, the cuticula is found to be divided into two layers, an outer, structureless one which is the corneal cuticula of the visual organs, and an inner layer; the retinidial cuticula filled with the ultimate ramifications of the hypodermic nerves.

It is probable then, that where the so-called eyes in reality consist of hardly more than pigment-spots, it is useless to expect in these simple organs, structures which would deserve the titles of lens, vitreous body, choroid iris, and so forth. Nevertheless they are organs of sense and may be justly termed visual organs; though the mode of their operation may be concealed from us as yet, or may never be revealed, because they belong to functions which are utterly outside the reach of our experience. To use the words of Mr. Patten (op. cit. p. 570) "If we study the structure of the eyes of *Pecten* we shall find that the parts really have the function that their names and composition indicate. We see a constant purpose in view, a concentration of the rays of light and the formation of inverted images of external objects upon a sensitive nervous layer, the arrangement of whose elements shows a definite relation to the direction of the rays of light."

The curvature of the cornea and the size of the pupil are regulated by means of contractile fibres. The convexity of the former can be increased, and the opening of the pupil diminished to half its ordinary diameter. Strong chemical irritants of one kind cause contraction, while others again make the cornea nearly flat and widely extend the pupil. The lens is a true optical lens, forming a perfect inverted image on the percipient elements, namely the rods with their contained retinidia. If, when the eye is on the stage of the microscope, a fine needle dipped in white paint is inserted between the eye and the objective, a perfect inverted image will be seen in the depths of the eye, and much larger and more distant objects are represented with exactly the same precision if presented in the right position. Thus Mr. Patten found that by focussing upon the inner surface of the lens, an inverted image of the moving tree-tops in front of the window could be seen. I have tried the same experiment in various different ways, but with only a moderate amount of success, because of imperfect manipulation in isolating the eyes. I have tried it with the tentacular eyes and with the mantle eyes, and with the shell eyes of *Trigonia lamarckii*.

With the whole of these and the tentacular eyes of *Cerithium ebeninum*, Brug., (See pl. v., fig. 6) I have been able easily to obtain inverted images of different objects especially the gas lamps with a glass shade under which I was operating, and of the window of the room where my investigations are carried on. But the slightest failure in the precautions necessary for success, prevented these results. The eyes must be perfectly fresh and uninjured, and mounted with the greatest care. The method which succeeded best was to take the eye from the animal immediately after death and drop it into osmic acid; then transferring it to absolute alcohol and clove oil, and mount it in the ordinary way, taking care to avoid any undue pressure. Only experience teaches the length of time required for exposure to the re-agents, for the tissues are easily destroyed.

I shall conclude the reference to Mr. Patten's observations by the following important quotation. In answer to the question as to where the image is formed, he says, "This may be easily determined by following successively the layers of the eye as far as the tapetum. First are seen the minute hexagonal ends of the corneal cells, then the radiating and circular fibres of the pseudo-cornea and outer surface of the lens, followed by the large irregularly-shaped cells of the latter; then the outer layer of ganglionic cells above the perfectly regular but faint outline of the rods, (which may be recognized by their resemblance to the figures seen by viewing the prepared isolated retina from above or below),—and lastly, the tapetum itself, from which issues the red light from the pigment below. Just before reaching the

tapetum, the image of any object in front of the pupil will be seen with the greatest distinctness, diminishing in definition according as the objective of the microscope is raised or lowered. But the rods also lie above the tapetum, so that upon them the image must be formed. A remarkable phenomenon may be observed, by focussing between the argentea and the place where the image formed by the lens is seen with the greatest distinctness, for there one sees a double image, less distinct towards the argentea, but increasing in sharpness towards the focal point of the eye, where the two images ultimately fuse to form a single one. The only explanation I have to offer for the origin of this second image is that it is a reflected one of the first, formed by the curved surface of the argentea. A plain mirror would never reflect an image formed by a lens, since the rays of light would be dispersed; neither would the image be reproduced by a concave mirror, unless the curvature was such that the divergent rays coming from the lens, impinged upon the reflecting surface, at right angles to the tangent at that point. In that case each reflected ray would coincide with the incident one, and a reflected repetition of the lenticular image would be reproduced, both being formed at the same point. The exact relation between the focal distance of a lens like that of *Pecten*, and the radius of the concave mirror which would again unite the rays, has not been determined. (Pl. 32, fig. 149)."

It will serve to make the references more complete if I here give a very interesting section of another kind of eye in which the various organs are singularly clear and interesting. It is a simple eye of an embryo of a Cephalopod. It was a section made by Dr. Haswell of the Sydney University, who very kindly communicated it to me that I might subject it to microscopic examination and make the accompanying drawing. The section is one of an embryo Octopus in the egg and probably just before extrusion; at any rate the stage is that at which the organs have become fully formed and the yolk-sac has been entirely absorbed. The eggs were obtained in Port Jackson, but unfortunately the species from which they were taken was not determined and of course no specific character can be made out from the embryo. At pl. x., fig. 15, I have given a drawing of one of the sections, or rather that portion of it which includes the eye-chamber as far as it has been developed. The explanation of the letters in the plate will make the section easily intelligible. *a* cornea or integument, *b* iris, *c* ciliary body, *d* aqueous chamber, *e* internal rods of the retina, *f* pigment-layer, *g* external layer of rods, *h* body of optic ganglion, *i i* are what are called the white bodies, which Dr. Ray Lankester believes to be the material at the expense of which the optic ganglion is nourished; *j* lens, but for further information on this somewhat technical

subject readers must be referred to the observations on the development of the Cephalopoda by Dr. Ray Lankester in the "Quarterly Journal of Microscopical Science" for 1875, xv., p. 87.

There are many peculiarities in the eyes of Cephalopoda which it would be beside my purpose to enter upon here; but I may mention that the cornea is absent from the eye of *Nautilus* as well as the lens. The integument which replaces the cornea has a pupil-like orifice which leads into the interior of the bulb. This integument is perforated in the adult *Octopus* and the anterior surface of the bulb is bathed by water. The space which communicates with the exterior is not only continued through the optic cleft as far as the lens, but also extends more or less around the bulb. The base of the bulb is formed by a cartilaginous capsule. Around the pupil this becomes converted into the cartilage of the iris. Outside and behind this optic capsule (let it be observed that we are now dealing with an adult eye and not entirely with the section) is the ganglion of the optic nerve in the periphery of which there is the whitish organ which projects more or less forwards. Behind this is a layer of muscles and then a silvery membrane (*argenticia externa*) reaching to the edge of the pupil, investing the bulb on its inner face. Internally is the *argenticia interna*. The nerves pass by pores in the capsule to the retina. This is divided into an internal portion containing the perceptive elements, separated from the outer portion by a layer of pigment. The substance of the above description of the adult eye is taken from Gegenbaur (Comp. Anat.) and Ray Lankester.

Especial attention is called in this section to the line of division between the internal and external layer of rods of the retina. The ends of the internal layer project through the pigment membrane in a series of remarkable bodies and there seems to be no connection between them and an external layer of nerve substance. This will be the subject of further investigation. Finally it may be mentioned that the "ciliary body" is a series of lamellæ which invest the edge of the lens.

I fully anticipate that this novelty of eyes in the shell of *Patella*, and, as I shall show of many other shells of different genera, will only make its way with difficulty, especially when it is remembered that such an experienced naturalist as Mr. Mosely searched for them in vain in a European species of the same genus. Moreover he expressly states that he believes that Chitonidæ is the only family where the arrangements of the peculiar structure render such organs possible. Therefore I warn observers beforehand of the great difficulty attendant upon the observation of these eyes. They are much more minute than those in the shell of *Chiton*, and they are so often hidden in the rough inequalities on the surface of the shell, as well as by foreign matters and the corrosive

action of the sea, that very few shells can be found in which they are easily visible, and rarely any in which they are arranged in their full symmetry as in the plate. A thousand different causes may interfere to destroy or remove the structures, so that the symmetry of the whole arrangement becomes interfered with and rendered, in most shells, quite unrecognizable. It should also be remembered that in every case, or nearly every case, the eyes are hidden in a little depression or pit which conceals them very effectually when the shell is dry. Various methods must be adopted so as to view the organs under different conditions and to familiarize ourselves with their aspects. If the shell surface be cleaned with acid the eyes are destroyed effectually, but the position they occupy becomes easily visible. The shell-surface then can be cleaned of foreign matter and the plan of the arrangement becomes apparent. Prolonged maceration of the shell in caustic potash cleanses it from impurities and though it does not destroy the eyes like the acid, yet it effects them to some extent, and then they are no longer visible except in a few cases. Prolonged maceration in dilute acid, so as to lead to partial decalcification, reveals many other portions of the structure which are invisible otherwise. Observers should also be warned that other things may be mistaken for the eyes, especially the peculiar appearance on the surface of the shell which a reflection of light from little asperities causes. I have found also that very hard brushing of the surface has a tendency to remove the eyes. The best way probably is to cleanse and macerate a number of shells by all the different methods and subject them to minute examination side by side.

Before passing on to other species I must try to show how it is possible to reconcile my observations with what other observers have stated. Every one knows what has been regarded hitherto as the characteristic structure of the ordinary bivalve. The following quotation on the subject is taken from Dr. Carpenter's work on the microscope, who takes as a type the group of Margaritaceæ. He says, "In all these shells we readily distinguish the existence of two distinct layers; an external, of a brownish-yellow colour; and an internal which has a pearly or nacreous aspect, and is commonly of a lighter hue. The structure of the outer layer may be conveniently studied in the shell of *Pinna*, in which it commonly projects beyond the inner, and there often forms laminae sufficiently thin and transparent to exhibit the general nature of its organisation without any artificial reduction. If a small portion of such a lamina be examined with a low magnifying power, even without any preparation by transmitted light, each of its surfaces will present very much the appearance of a honey-comb; whilst its broken edge exhibits an aspect which

is evidently fibrous to the eye, but which, when examined under the microscope with reflected light, resembles that of an assemblage of basaltic columns. The shell is thus seen to be composed of a vast number of prisms, having a tolerably uniform size, and usually presenting an approach to the hexagonal shape. These are arranged perpendicularly (or nearly so) to the surface of the laminae of the shell; so that its thickness is formed by their length, and its two surfaces by their extremities. A more satisfactory view of these prisms is obtained by grinding down a lamina until it possesses a high degree of transparency; and it is then seen that the prisms themselves appear to be composed of a very homogeneous substance; but that they are separated by definite and very strongly-marked lines of division. When such a lamina is submitted to the action of dilute acid, so as to dissolve away the carbonate of lime, a tolerably firm and consistent membrane is left, which exhibits the prismatic structure just as perfectly as did the original shell; the hexagonal divisions being apparently those of the walls of cells resembling those of the pith or bark of a plant, in which the cells are frequently hexagonal prisms. In very thin natural laminae the nuclei can often be plainly distinguished." The Microscope and its Revelations by W. Carpenter, M.D., London, 1857, 2nd edit. pp. 546-7.

I believe the basaltic structure here referred to is a portion of the outer surface; and the hexagonal cells are, in the species I mention, the nerve-tubes or portions of the capsules for the sense-organs. I do not undertake to say that this is the case in the particular species referred to by Dr. Carpenter, because I have not examined it. But I have seen a similar structure in shells I have examined which I explain as above.

Yet as a general rule I am hardly inclined to state that there is a uniformity in the way in which the plates of shelly matter succeed each other which is applicable to every species. They are continually being added as the growth of the shell progresses.

It has already been observed that the shell is not to be regarded as an inorganic investiture; but one which is developed with the growth of the animal, and has an intimate association with all that is considered living structure. The mere fact of its taking for its constituents elements which are not found in other portions of its economy, and which belong more properly to the mineral kingdom, does not place it outside the pale of living tissue. It lives with the animal and is just as much subject to disease or dissolution as any other part. In a section taken from the columella of *Cerithium ebeninum*, Brug., I have found no less than 15 or 16 thin layers of new shelly matter added in succession from within. All these are regularly perforated by the tubes or nerve-channels. There are, it would seem, two kinds of growth in the shell; one from

inside, and the other at the periphery. The inside lining is composed of the thinnest layers of shell, and partakes of the colour of the nerve-tissue, which, as we shall see by and by differs very much in different genera and species. But roughly speaking, as I have already stated there is a division into certain plates, three or four in number. I have given a description already of one such section from outwards to within. At the risk of being tedious I will repeat what I have observed in *Patella tramoserica*, Martyn, in thin sections under the microscope, proceeding from within outwards. First there is the thin layer of fibrous tissue already described as being full of pores for the entry or exit of the nerves. The calcareous structure is faintly visible amidst the membranous sheaths, in the form of faint striæ inclined at an angle of 45° , in two opposite directions. Then succeeds the nacreous lining in which very fine nerve-channels can be seen, having an irregular course, with branches at intervals. Some of these can be followed a considerable distance into the substance of the shell, and they are conspicuous for their irregular course and their alternate dilatation and narrowing. There are fine lines of membrane lying parallel with one another, which are occasionally darkened by granular substance, black and brown, appearing more like foreign matter enclosed by the growth of the shell than anything else. The lines of growth which at their edges have lines of very fine parallel rods not wider than the width of the series of cells which seems to compose them are distinctly visible. Finally there is the outer layer or fibrous plate containing the micropores and the eyes already referred to. Probably outside this there is in nearly all shells an outer layer of membrane or a periostraca; but it has generally disappeared in shells that have been out of the water any length of time.

The inner or nacreous lining though apparently opaque, with a strong golden or silvery lustre, is in reality transparent; and the golden or silvery colour is due to fine lines of membrane which pass down the interior lining of the shell. Besides this there is a thin inner plate next to the mantle which is full of transverse tubes. They appear to me, in sections, not to differ in structure from the fibres of the upper layer, though the result is very different. They are a series of somewhat narrower and more regular tubes and fibres of membrane, passing at an inclination at right angles to the fibres of the upper plate, from one side of the lining to the other. They are dotted at intervals with lines of darker material, which are sometimes a series of small rounded cells.

The lines of membrane seen with the naked eye in the interior of the shell correspond with the strike of the nacreous plates on the periphery of the shell. The fibres are sometimes separated by intervals or spaces. They are probably the folds spoken of by

many observers as being the cause of the nacreous iridescence as already stated. The whole surface of the inner lining is perforated by exceedingly minute pores, apparently at regular intervals, sometimes perforating the fibres themselves. They are about $\frac{1}{100}$ of an inch in diameter. The fibres and the lines of darkened cells already referred to give a striated appearance to the nacre which is different from any other tissue. There are little oblong lacunæ occurring at intervals, and some of these appear to be associated with the transverse bands of colour already referred to. Some of these transverse bands are no doubt strands of nerve-tissue which have been partly destroyed in making the section.

If the species of *Patella* with which we are dealing be treated with acid, so as to decalcify some of the plates, the thin membranaceous tissue can be detached and placed under the microscope, where the folds are still visible and the fine nerve-fibres that formerly passed along its surface can be detected, though of course much broken, twisted, and out of position. If the interior of the shell be closely examined it will be seen that the acid has eaten into some of the eye-chambers and destroyed every thing except the lining of pigment-cells. This coating however, is not universal in all the eye-chambers. It should be mentioned that the membrane and membranous fibres seen in section are best visible with the aid of the polariscope.

A fourth layer is found in limpets in what is called the spathula, which consists of a porcellaneous structure very much like the second outer layer, but which differs apparently in this, that its lower surface is highly polished, and under the microscope has a somewhat papillated appearance, consisting of minute pits somewhat like the surface of a thimble, in amongst larger rugosities, yet in no case rising higher than just sufficient to give a somewhat dead appearance to the enamel. This latter cracks like old china in the older shells and those which have had even a trifling amount of exposure. Under a moderate power of the microscope, distinct pores can be perceived.

A peculiarity with this spathula is the mode in which it varies in its colour; being brown, yellow, orange, olive, pale bluish-green, and mottled brown, sometimes opaque and sometimes transparent. Round the spathula, as already stated, there is a distinct horseshoe shaped depression which limits it, and at the outer edge of which I believe is the principal exit for the nerves. The edge of this spathula-plate is gradually bevelled off, and here it is, that with microscopic aid, pores can be seen. In nearly all the shells that I have examined, I notice a peculiarity in the spathula which is that the colouring matter seems to be associated with a kind of granular structure, or as if flecks and fragments of a lighter colour were floating about in a transparent medium. In very many shells

there are rounded and irregularly-shaped nacreous nodules, like the pores which one sees on the inside of the freshwater mussel.

We will now turn to the consideration of the structure of a non-nacreous shell, namely *Cerithium ebeninum*, Bruguière: a turriculated univalve shell, common at Port Jackson. (See fig. 5 back and front views of shell.) It has ten or eleven whorls usually; is conspicuously nodose, and spirally grooved; of uniform dull brown colour, a spreading mouth and highly enamelled interior. Around the mouth there is a margin of rich brown colour on the outer lip and then an irregular brownish-white interval, streaked and clouded with a deeper fawn-colour, until in the throat it merges into a uniform deep chocolate-brown. If a section be made of the shell the brilliancy and glassy smooth polish of the enamel in the upper chambers of the spire render it a most beautiful and interesting object. It is often a wonder to me that shells are not more largely used for decorative and ornamental purposes than they are. This species cut in half shows such brilliancy and beauty of colour inside that with a little manipulation it could be manufactured into an attractive brooch.

The highly enamelled lining is banded or clouded by a rich reddish-brown, which on the opaque outside deepens almost into a black colour. Under the microscope the enamel is seen to be colored by very fine lines of reddish-brown membrane which permeate the whole shelly substance. Sections of the shell show transverse waving-lines of a rich reddish-brown intercalated with strata of lighter colour, or even white in extremely fine lines proceeding from the columella to the shell-surface. These lines though waved and curved, are crossed irregularly by transparent lines of what I consider to be nerve-fibres which divaricate and anastomose until they terminate on the floor of the whorl or outside of the shell.

It is difficult to make this understood without a great number of sections, for the structure is so extremely complicated; but I believe its explanation to be as follows:—there is a nerve-ganglion in the columella of the shell, which is found in a spiral line through its centre and for the whole of its extent. It is of a reddish-brown colour and of silky lustre. The nerve-fibres which proceed from it through the shelly matter run in closely parallel lines to the outer or inner lining of the shell. They curve apart in lines of two different directions according as they are intended for the inner or outer surface, out of which they pass by the tubes already referred to. A section of the whole shell shows the inner lining of the whorls to be a thin transparent stratum penetrated by innumerable pores. In this species they are not so visible on the outer surface.

It will be observed from this description of *Patella tramoserica*, Martyn, and *Cerithium ebeninum*, Brug., that there is a distinct

arrangement for the exit or entry of nerve-fibres on the inside as well as the outside of the shell. Now, if I am right in my assertion that there is a large nerve-ganglion in the columella of the shell, then we must expect large means of communication between this nervous centre and the soft tissues which lie inside the whorls of the shell. There are equally extensive communications from the sense-organs outside. I have just now stated that they are with difficulty visible in the last named species, but in sufficiently thin sections they are equally conspicuous. What has been observed with reference to the eyes and sense-organs on the outside of this species will be mentioned further on. It should be mentioned also that the different strata of colour, forming fine lines of division, are not always due to different plates of shelly matter, but apparently to differences in the strata or lines of nerve tissue and in the amount of pigment connected with these lines, which varies in a manner I cannot explain. Externally the shell is marked by no bands of colour, except that the nodules and spiral lines are very much darker than the rest of the shell, giving it the appearance in fact of a scorched and blackened piece of wood.

In this species (*Cerithium ebeninum*) there is an absence of any appearance of what is called fibrous structure, that is to say, plates of shelly matter with oblique fibres arranged in successive strata at right angles to one another. This shell is of unusual hardness, requiring considerable force to break it. This is the more singular when we reflect how completely permeated it is with animal matter. When once the animal dies, unless the shell be carefully kept from exposure to the weathering influences of air and moisture it soon falls into decay.

Now this shell is to all appearance non-nacreous, and yet an attentive examination of the shell will show a certain amount of iridescence in the shell structure. In fact nacreous iridescence seems to depend upon the transparency of the plates and the colour of the intercalated membrane which is thus to be seen through the shelly matter. There is a hard, white, compact substance in the shells of *Chama gigas*, which is so hard as to be worked like stone into bracelets and ornaments; yet even this, hard as it is, will be found to contain, under the microscope, alternate lines of transparent shelly matter, which with the aid of the membrane underneath, give rise to a nacreous appearance. It is generally thought that only a few shells are nacreous; but examination with microscopic aid shows that the fact is the other way, only that it is but faintly perceptible in most kinds. This is what we might reasonably expect; for if nacre be due to the intercalation of finely divided membranous tissue, all shells partake of this structure. If a chip is taken off the enamel, the transparent lines are easily visible with transmitted light.

Though the full meaning of all the different portions of shell-structure is not clear to us, yet we can infer the purpose of the fibres being at right angles to each other in the different strata, which is to give great strength. We see also how it is that with the death of the animal the shell suffers disintegration, unless it is preserved from the action of light, heat, and moisture on the animal tissue which it contains. On the coral reefs of the East one sees this plainly in the ruin and destruction that falls upon the hardest and most compact shells once the animal no longer lives to give them animation and support.

Let us now pass on to the consideration of other shells besides *Patella tramoserica*, Martyn, in which I have observed eyes of a similar nature to those on the shell surface of *Chiton* and *Patella*.

First on the list is *Acmaea septiformis*, Reeve, a small shell of the limpet kind belonging to a genus, which, as already stated, has a gill-plume at the back of the neck, instead of a series of gill-filaments all round the foot. This species is a depressed, conical shell with the apex anterior and from 40 to 50 somewhat irregular and depressed ribs. These ribs are sometimes slightly undulating and as they have dark lines between them, this gives the external aspect of the shell an appearance of tortoise-shell. The same lines of colour are thickened and bifurcate at the larger lines of growth; so that when held against the light, the colouring is light brown, clouded with very dark spots and undulating lines. The inside of the shell is not nacreous, or at least not so conspicuously so, as the species of *Patella* we have been dealing with last. There is a bluish-white lining inside, except at the spathula and margin. The latter is but slightly undulated by the ribs, and is variegated at these points with spots of much darker brown colour. The surface of the shell does not present the same symmetrical arrangement of the eye-points as that which is found in the last species. The surface is very closely and irregularly pitted all over with minute depressions, surrounded by a ring of pigment. In the centre of this is the eye, always of minute size with a small dot in the centre, and lying at the bottom of the depressions spoken of. The eyes themselves are extremely difficult to see unless that their presence can be always inferred from the peculiar gem-like sparkling of the crystalline corneas. They are so closely packed together and so minute that it is utterly impossible to form an estimate of their numbers except near the margin. I have done no more in the case of this shell than merely ascertain the presence of these shell-eyes, and have not as yet made any experiments by subjecting the shell to the action of re-agents, or more closely examined the organs themselves.

Siphonaria diemenensis, Quoy, is another of the conical shells which will amply reward the observer who examines it for the

optical peculiarities that are seen in the previous two species. The eyes are of much larger size and not so deeply set as in the last case. They give the shell a very beautiful appearance because of the multitudes of them which beset the surface; but still there is no approach to the symmetrical arrangement which I have seen in the case of *Patella*. On making my first examination of *Siphonaria* I did not find the eyes, and was almost giving up the search when a fresh shell showed me the multitude and size of the organs. In proportion as the shell is dry and withered, so is it difficult to see them, and in those which have been kept in spirits for any length of time it is nearly impossible.

At present so much is required to complete observations that I am reluctant to give any list of other species in which it seems to me that I have observed shell-eyes. If the organs be such as I imagine them, then I may say that there are many shells I have examined on which some such have been observed; though the number may be very small in some species, especially those with a compact outer plate and high colouring, and porcellaneous shells. Still the proportionate number of shells I have carefully inspected is small. The difficulty of dealing with them can be easily understood when it is remembered how often shells are overgrown by a thick matted periostraca in which algæ are extensively entangled, and all sorts of foreign organisms growing. To remove this must, in nine cases out of ten, destroy all traces of eyes. Persons are greatly mistaken who think that the brilliant tropical shells, the cones and the cowries which adorn most houses, are found upon the coral reefs in the way in which they beautify the sideboards and the mantelpieces. In their living state they are anything but attractive objects, and are, without exception, disguised in a thick greenish and slimy coat which requires much care, patience and labour to remove. Much of this belongs to the living tissue, and it has never been taken into account by collectors.

The naturalists in the early stages of that portion of zoology which occupied itself with the Mollusca, took no heed of anything except the shell. But even when more reasonable and sensible systems had been followed, the outside of the shell and its clothing received no attention, and it is not known except in a very few cases. I well remember the effect upon my own mind, when landing for the first time upon the great Australian Barrier Reef, which may be called an emporium for the glories of the deep, or the spoils of the ocean, especially in shells. I began to look about for one of the most beautiful of these treasures, which, to my mind can vie with even the *Conus gloria-maris*. I mean *Conus marmoreus* with its intense blackish-brown hue, thickly studded with broad, tongue-shaped white marks. Having been informed that it was common, I expected to see it easily, since its colouring

is so conspicuous, though it is not as a matter of fact so common as represented. But the difficulty really was to see and distinguish them. They are dirty dull green shells, looking as if they had been stranded on the withered corals by a very muddy tide. No one would suspect the existence of the beautiful pattern underneath, and this is true of all the cones, the Strombidæ or wing-shells, and in fact of all the tropical beauties except the porcellaneous cowries and a few others. What covers the shell is a periostraca of living tissue, a very perishable material which can only be studied when the shell is taken fresh from the sea. It soon perishes if allowed to dry; and spirit, or indeed any preserving fluid that has been devised as yet, so alters the structures in the course of time that it interferes to some extent at least with the condition of the tissues, and prevents their recognition.

Now it cannot be too often insisted upon, that in this external covering, any sense-organs which are possessed by the animal will be found to exist. A little reflection must convince us, for instance that the provisions for sight which are found on the tentacles of the animal can be of no use except for guidance in walking and taking food. The animal and the interior of its shell must remain absolutely in darkness, and worse off in point of seeing than any of the molluscan beings in the animal kingdom. The discovery by Mr. Mosely of the eyes in *Chiton* shows us that some other provision exists, and that vision is given to these animals on an extremely liberal scale. It would be a most singular thing in nature if the Chitonidæ were the only family where such sense-organs existed. I can well understand however that a search will be often unsuccessfully made upon shells by those who wish to follow up the observations of Mr. Mosely. But does the observer know what has happened to his shell before it came into his possession? The periostraca and all the living external tissues have been roughly stripped off, and it has been scrubbed and brushed and scoured till the hard and durable shell-substance has alone remained. It has been cleansed with acids besides a liberal alkaline cleansing by means of soap-suds &c. In nine cases out of ten, oriental shells are collected in India and the Indian Archipelago by the natives, who leave them in the sun for the animal to rot out of them and the shell to be bleached by the sun. They are then again soaked in sea-water to remove the decomposed tissues and the odoriferous properties. It is no wonder therefore that if there were eyes or any other organs they have hitherto escaped observation, nor will they be recognized until the shell on the living animal is studied in every case.

Anatina tasmanica, Reeve, is an ovate, translucent widely-gaping shell, about an inch and a-half in length, and half that width, with a peculiar split near the umbones like all the members

of that genus. The outside of the shell is rather rough, and, even without the assistance of a lens, this is seen to be due to a number of little crystalline projections which stud the surface quite irregularly. Under the microscope the upper part of the shell is seen to be covered with an immense number of little ridges on which the eyes are located for the most part, though some are found in the grooves between each ridge. The number of eyes is considerable, and both sides of the shell seem to be endowed alike. On viewing the shell structure by transmitted light, a somewhat broad or widened dark margin is perceived round each of the eyes, forming what may be regarded as the pigment-coat. The pupil itself is not easily seen. In a few specimens it is only slightly darker than the surrounding crystalline lens; but by transmitted light it appears in nearly all. The eyes so thickly cover the surface of the shell that it looks mottled and clouded. Some of them are of large size, and the pupil very large. This shell ought to be one of the best for making observations upon, and it certainly is a very good instance of these newly discovered optical arrangements, from the wonderful numbers of the eyes on the shell-surface. The nerve structure of the shell has only been partially examined. There are two or three other species in Australia, all with the same peculiarities.

But I come now to a species which, if I am right in what I suggest as to the meaning of its structure, is certainly the most wonderful instance that has come under my notice, while it gives us a clue to the way in which we must regard these multitudes of ocular organs. *Trigonia* it will be remembered, is one of these remarkable genera of shells, which help to give the fauna of Australia so peculiar and ancient a character. The *Trigoniæ* are principally Mesozoic, being especially abundant and characteristic fossils of the secondary deposits from the Lias to the Cretaceous. Two or three species occur in the Australian tertiary rocks; but there are four living species in our seas. The shell is trigonal with tubercles and radiating ribs, while the two long lamellar teeth in one valve and their sockets in another have conspicuous vertical grooves. The interior of the shell is brilliantly nacreous and most delicately coloured. If the surface-structure of *Trigonia lamarckii*, Gray, be examined with a lens, it will be noticed that the whole is shagreened with minute glassy tubercles, lying close together, like a pavement of symmetrical mosaic work and forming one of the principal beauties of the species. Under the microscope it is seen that the shagreened appearance is due to the surface of the valve being divided into a number of hexagonal facets, in the centre of which there is what Dr. Woodward and other observers regarded as a nucleus, but which is seen, by powerful magnifiers, to be due to a curiously formed projection

like the knob or handle of a door. This is a crystalline lens, and the basal structure is very similar to the faceted structure of an insect's eye. The facets are certainly no bigger and of uniform size. The valves are provided with about 20 ribs beset at intervals with flattened raised tubercles, and these tubercles are covered with round bull's-eye-like lenses instead of the hexagonal facets on the body of the shell. Towards the outer edge of both species (*T. lamarckii*, Gray, and *T. margaritacea*, Lamarck,) the faceted outer coating becomes gradually merged into a corrugated membrane or periostraca, from which the faceted structure gradually disappears. At the most moderate computation I can make, there are at least 12,000 eyes on each valve but probably this is far within the estimate. (See figs. 25 and 26.)

On making a section through the shell-substance of the valve and using high magnifying powers, we find that every facet covers a small eye-capsule similar in office to the pseudocone of the insect's eye, except in this that there is a line of division in the middle of the capsule which contains the rods and the optic nerve beneath. The optic nerve also sends forth small fibres towards the outer surface. The manner in which the optic nerve is conveyed from the large ganglion in the shell substance to the base of the eye-capsule, is better conveyed by a diagram than by any description. At pl. x., fig. 16, I have given a small portion of a section made transversely to the ribs, that is to say, cutting through three ribs in succession. Here it will be seen that there is a crowd of eye-capsules inclined at every angle according to their position on the slope of the ribs; some of these are covered with highly refractive round bull's-eye-like lenses and others with a faceted arrangement and the knob-like lenses already described. From these the nerves radiate out in a fan-like fashion when they come from the valley between the ribs, or collect into one column from a reversed fan-shape when they come from the rib or its slopes. A reference to the plate will make the meaning of this quite clear. A section made at right angles to this, gives slightly different results, but only arising from the different position in which the same structures are seen. It will be noticed also in the plate that when the optic nerves have spread out in a radiate fashion for a certain distance they seem to terminate, though in reality there is no termination: there is simply an absence of pigment cells, and the nerve-sheaths become more transparent until they join a large optical ganglion. Between the base of the capsules also, or rather beneath the base of the capsules, there is a dark line or stratum of tissue where the nerves are more difficult to trace. It seems as if the darkness is due to pigment cells, and the line where they cease is as clearly marked as the line on the upper surface separating the clear glassy-looking eye-capsules from this dark layer.

There are between 350 and 400 raised tubercles on the ribs, which tubercles are somewhat flattened and hatchet-shaped on the surface. They are studded front and back with the same crystalline pavement. It is not difficult to assign a reason for this arrangement. The eyes having no movement of their own are located in every position to command a prospect all around. Direct vertical vision is secured by the eyes on the surface, and horizontal vision at every angle from the slopes and sides of the tubercle.

The nacre of *Trigonia* is transparent in all the species, but it is so abundantly permeated with nerve-tissue as to be opaque for microscopic purposes except in the thinnest sections. I believe that the colour of the nerve-tissue which appears so dark and black in sections, is purplish with a greenish iridescence, and this is seen on the inner lining of most of the shells; but the purplish tint is also visible on the outer plate or tegmentum.

The eyes have a distinct pupil and are easily examined in section. Though the lenses are singularly bright and lying close together, yet there are interstices with micropores upon them. There are smaller tubes seen in amongst those carrying the optic nerves and crossing them at right angles. The office of these I have not satisfactorily made out. The eye-capsules it may be added, are very easily examined, but I cannot be sure that all carry that peculiar knob and an eye with lens, retina and optic nerve of the invertebrate type, because in making the sections the utmost caution could not prevent the disappearance or displacement of those minute and delicate organs.

Now what is the meaning of this wonderful aggregation of visual organs; or is there anything like it to be found in nature? Nothing equal to it, I think we may say with certainty. The only things that can be likened to the valves of *Trigonia* are the Ommatidia of the insect world. Those who are not familiar with the technology which I have already explained, at least know what is meant by the brown, spherical eyes on the head of the too-familiar house-fly. All of us know it and most of us have seen the hundreds or thousands of hexagonal facets under a lens. In the head of the common drone-fly there are said to be between 4,000 and 5,000 eye-facets. Usually in the shell-eyes of Mollusca they occupy a much larger space, but here they do not, and I therefore ask my readers to estimate the difference in size between a drone-fly's head and the valve of a *Trigonia*; and then take into account what must be the powers of vision of these prodigies amongst the sight-seers.

Now considering that the eyes are thus on the surface of the two valves of the shell, is it a very great stretch of hypothesis to regard the two valves as the representatives of the sides of the

insect's head, and the large nerve-ganglion in the substance of the shell as the cerebral ganglion of the species? It seems to me that the shell in this case should be regarded as a brain-case, as well as a box for the enclosure of the soft tissues of the animal, and thus a new office for the shells of Mollusca comes into view. Most persons will say at once that this case may be quite exceptional, but I will deal with that suggestion presently.

The cerebral ganglion, as I must be allowed to call it, in the substance of the shell, has already been described in speaking of the nervous tissue. It may be seen, I think even on the outside of the shell, where it is marked by certain dark lines of pigment. In *Trigonia lamarckii*, Gray, these may be traced in the form of double lines of darker colouring matter corresponding with the former lines of growth. They are equally visible on the outside and the inside of the shell. So here is an explanation of the meaning of these dark bands of colour, though the reason for them is not so readily assigned. The nerve-sheaths connected with these ganglia pass round the shell to the anterior adductor muscle whence they issue into the soft parts of the animal. Here they may be seen in section almost like the pipes of an organ, and larger than any nerve-strand in the soft parts as far as my observation extends.

Now with the evidence before me of the small size of the ganglia in the soft parts of *Trigonia* I am inclined to regard the ganglia in the shell as a real cerebral centre from which the whole body is supplied, and the order which the nervous fibres take is from this centre, to the eyes on one side, and the soft parts on the other.

But these Mollusks have hitherto been classed amongst the acephalous or headless Mollusks, and yet we see that such a description is entirely out of place. To say nothing of the eyes, the cerebral ganglion contained in its shelly brain-case, should lift it quite out of the category of headless animals. Hitherto it has been said and taken for granted without dispute that the relatively feeble development of the cerebral ganglia in the bivalves is due to the absence of a head and the accompanying sensory organs of a head. But what is entitled to the name of a head, if not these valves provided unmistakably with a large nervous centre and so richly endowed with sensory organs.

But then the question arises, how far is this structure in the case of one species of *Trigonia* exceptional? Are the other members of the genus similarly endowed, or are there other genera to which the same characters are to be ascribed? That *Trigonia lamarckii*, Gray, is a richly endowed shell, there cannot be any doubt. No shell that I have met with as yet has the eyes and the eye-facets so beautifully marked, but I think I have seen something nearly equal to it amongst *Pectens*. No shell that I have met with as yet presents such beautiful and easily accessible ganglia.

But when this is said, it must be admitted also that the relative number of shells examined is but small, and I have seen quite enough to convince me that characters as wonderful as those of *Trigonia lamareckii*, Gray, will be easily found, and that in respect to the sense organs the species is not so very exceptional after all.

I have already stated that there is a nervous ganglion in the columella of certain univalves, with accessory sense-organs. Hence I regard the shell of these univalves as being a cephalic ganglion case. But if this be so, we naturally enquire what about the operculum, for this is justly regarded as the homologue of the second valve amongst bivalves. In answer to this I may say that I have found, in the calcareous opercula of a few species, well-marked nervous ganglia as well as accessory sense-organs. In nearly all the species of *Nerita* known to me, the operculum is covered with small oval or hemispherical projections of a transparent or glassy nature. These when examined are found to be abundantly provided with sense-organs and attached nerves. Moreover amongst many species of *Turbo*, the calcareous operculum is thickly studded with opaque or glassy tubercles and projections, some of considerable size. All of these are abundantly supplied with nerves, and some of them have well-formed eyes upon them, while others have abundant sheaths of nerves for sense-organs. There can be no doubt that when the animal is comfortably housed in its shell with the door of the operculum shut against intruders, it is able to take the fullest cognizance of what is going on outside by means of the asperities and tubercles with which its door is beset.

Moreover the position of the ganglion in the operculum is precisely similar to that which it would occupy in the spiral of a univalve shell. In all the opercula now referred to, the nucleus is lateral, and it represents the spiral of a univalve shell, the outer curve corresponding with the outer lip, and the nucleus with the columella. Just inside this nucleus the ganglion is situated, and from it proceed an abundance of fine silky nerve-strands going in parallel lines to the periphery. In fact the whole operculum is, when seen in section, one mass of nervous structure. The silky lustre of the sheaths as well as the white shining character of the ganglion cells, give a peculiar brilliancy to the structure, which I think is ultimately due to the small highly refractive nerve-cells which are always found in neurospongium. At any rate this white iridescent character is a very good distinguishing feature for the tissue.

But it must be admitted that the structural differences between one species and another and one genus and another are often so great and perplexing that it is very difficult to pronounce any particular organ as exceptional or not. The operculum furnishes

a remarkable illustration of this. If a calcareous operculum is to be regarded as a modified second valve, it must be remembered that such an organ is possessed by a comparatively few species. A very large number of shells have horny opercula. The family of Trochidæ is a large group of nacreous shells with horny opercula. Some of these differ in important characters from the calcareous opercula, not only because they are chitinous, but also they have a central nucleus from which the organ increases in size by a many whorled circular spiral. In this there does not appear to be any centre of nervous matter, though there are clouds and bands of pigment and nerve-sheaths, and rarely, sense-organs in the shape of dark pigmented bodies which may be eyes. Such an operculum as this is found in many widely removed genera and families, as for instance, *Cerithium ebeninum*, Brug., *Trochocochlea teniata*, Lam., *Risella melanostoma*, Gmel., &c.

There is also a horny operculum with a lateral nucleus in some species, as for instance, *Littorina mauritiana*, Reeve, *Tectarius pyramidalis*, Quoy, and all the Purpuridæ, Tritonidæ and many other families. In all these there is the same peculiarity as to the clouding and banding with dark crimson-brown pigment. In the case of *Littorina mauritiana*, Reeve, there is somewhat questionable evidence of a nerve-ganglion. That is to say at the side of the nucleus corresponding with the columella there is an aggregation of ganglionic cells, but it is different in character from the nerve-cells in the case of the calcareous opercula and it is not connected with the sheathed nerve-fibres already described. I think that possibly the organ has the same office.

I am inclined to regard the pigment-cells and bands of colour in the chitinous opercula as connected with sense-organs, but as any investigations made on the subject are incomplete, I must defer giving any definite opinion. The whole question of the nature and office of the operculum requires a careful revision. Amongst the land-shells there are calcareo-chitinous opercula, and some with a lateral nucleus on one surface and a multispiral central nucleus on the other (*Hybocystis*); and there are curious modifications of the same organ amongst common littoral species in Australia; but for the present I wish to confine my observations to such as are connected with the possession of nervous centres and sense-organs.

Trigonia margaritacea, Lam. This is the large Tasmanian species to which reference has already been made. It is not usually so compact or so regular in appearance as *T. lamarckii*, Gray. The eyes are about the same size, though the species is much larger. But the character of the nerve-ganglia is different. A section shows a mass of whitish iridescent tissue under the upper plate containing the eye-capsule. It is composed of a very dense mass of nerve-fibres anastomosing with each other in all directions, and

finally terminating in a number of loose hair-like fibres hanging free, or looking as if they hung free in the substance of the shell. The same remarks which have been made on *Trigonia lamarckii*, Gray, apply generally to this shell. It has a purple nacre, shot with indigo shading off into green. One peculiarity of this shell is that the whole inner lining down to the very edges of the valve is closely covered with minute perforations out of which those hair-like nerve-fibres pass into the soft parts of the animal. Nothing of the kind is observed in *Trigonia lamarckii*, Gray, except a few foramina in the scars for the adductor muscle, and even these are very difficult to perceive; whereas in the other species, they are quite conspicuous. It becomes very difficult to account for the perforations near the edge of the shell, for one would think that there could be no permanent attachment between the nerve inside the shell and the mantle outside it. However the most remarkable peculiarity in this species is, that in some valves the interior has a few large eyes in pits or depressions, with a regular lens and pupil more like the eyes of *Chiton* than those of *Trigonia*. The only way to account for these structures is by supposing them to be eyes once in use at the edge of the mantle, which have been disused as the growth of the shell progressed. There is certainly a dim and worn appearance about them as if they had been for some time out of use.

At pl. xi., fig. 18, a figure is given of the peculiar way in which the nerve-fibres terminate in the substance of the nacre in this species.

In addition to this multiplicity of eyes, faceted or otherwise, amongst the Trigonidæ, arranged upon the insect type, or numerically similar to the visual organs of insects, we have multiplicity in a way that I have not seen noticed before. I have figured at the end of this paper two tentacular eyes of the common *Cerithium ebeninum*, Brug., to which reference has so often been made in these pages. These eyes are inserted on bulbs or lobes at the outer base of the tentacles. One of them, it will be perceived, is a dark pigmented cup somewhat enlarged at the outer end, on which is inserted a large semi-crystalline eye-ball. At the base of this are two small transparent eyes, and on what is apparently the cornea there is a small crystalline hemispherical protuberance as if a smaller eye were growing on the eye-ball.

But the lens in this case, though crystalline and transparent is by no means entirely so. It is full of flecks and blemishes or clouds of pigment in the interior, while there is a ring of pigment round the eye upon the cornea. The appearance is represented on pl. v., fig. 6.

On pl. vi., fig. 7, we have another form of multiplicity. This is an eye of the same species of shell, but very much of the

character of an insect's eye. Yet the small included eyes are not like facets: they seem to be formed of little rings of pigment in the substance of the eye-capsule. The two smaller eyes on the outer ring of pigment and below the cornea, are similar structures to the organs which have been described in the preceding paragraph.

This variety of structure, if surprising, is no novelty, for in the case of *Onchidium*, a shell-less Mollusk, there are hundreds of eyes on the back of many sizes and varieties. They were discovered by Dr. Karl Semper, who describes them and indeed the whole animal with a minuteness worthy of the high reputation of so great a naturalist and observer.* He states that he has found twenty different forms of eyes amongst the animals that he has examined, with one peculiarity about them that is worthy of special mention. The dorsal eyes are contained in little warty excrescences on the back, which give an appearance to the skin very much like the wrinkled leathery covering of a toad. The organs are of various sizes, disposed with the utmost irregularity, in fact like the eyes that I have been describing in many species. In addition to these dorsal eyes there are also two small tentacular eyes. These, however, belong to a different type, to appreciate which some little explanation is necessary.

There are two types of eyes found amongst the Vertebrates and Invertebrates. Amongst Mollusca the optic nerve becomes gradually merged in a layer of tissue called the retina, where the fibre-end forms a layer of rods and cones, called the columnar layer. In Vertebrata the optic nerve penetrates the outer membrane of the eye and spreads within it, but the ends of the nerve are turned away from the lens and have their free ends directed outwards. In the eyes on the tentacles of snails the rods are in a contrary position; that is the final spreading out of the nerve-fibres is towards the lens. Amongst Vertebrates the layer of rods and cones is pierced by the optic nerve, and in that particular spot there are no rods. Hence there is no vision, and it is known scientifically as the *blind spot*. There is no such spot usually amongst Invertebrates, at least there was none known until Dr. Karl Semper made his discoveries. The optic nerve was thought to extend over the outside of the eyes of Invertebrates, so that the columnar layer of rods and cones covered the whole inner surface of the retina without interruption. Dr. Karl Semper, however, while investigating the newly discovered eyes in *Onchidium*, found that the dorsal ones had the rods turned away from the lens, as in Vertebrata. These very interesting and surprising visual organs have a rather simple structure; but the

*Reisen im Archipel der Philippinen, Wiesbaden, 1877. Über Sehorgane vom Typus der Wirbelthieraugen auf dem Rücken von Schnecken.

type is identical with that of the Vertebrata. They have a *blind spot*, because the optic nerve pierces the lower side of the retina, and in both the layer of rods and cones forms the outer layer of the organ.

We have two if not three species of *Onchidium* in Port Jackson. The structure of the tubercles was made the subject of a paper by Dr. von Lendenfeld, in the 10th Volume (1st Series, p. 720) of the Proceedings of the Linnean Society of New South Wales. The result of his investigations was the announcement, that one of the species (*O. chameleon*, Brazier) has small papillæ and no eyes. The other species have generally three large eyes on each tubercle, and these he says are "situated laterally," by which probably he means the eyes. This is the species known as *O. dämeli*, Semper. As Dr. Lendenfeld's notes are very brief, I give them in full, premising with him, that he generally confirms Semper's observations.

"The eyes of *Onchidium dämeli* belong to Semper's Group I.; eyes with an epithelial retina. The epithelium of the tubercles is of identical structure in the species with, and the species without, dorsal eyes, and formed of an outer layer of low cylinder-cells, between which there are slender sensitive cells, particularly abundant round the eyes or on the sides of the tubercles of the *blind species*. The otolith-like concretions in the numerous vesicles of the dorsal skin are composed of carbonate of lime, and homologous to parts of the shell of other related pulmonates. The eyes multiply by division; semi-detached eyes, and such with a simple spherical pigment-layer, but with two lenses are not rare. The lens consists apparently of one single cell which retains its nucleus and vitality, and may divide into two. A sphincter-shaped circular accommodation muscle is clearly visible.

The retina is of a much more complicated nature than Semper, who had only spirit specimens at his disposal, was able to discover. The radiating fibres of the *nervus opticus* are interspersed with small ganglia cells. Below these follow cells with peculiar plano-concave bodies in them, which are highly refractive. These cells are broad and cylindrical. The final branches of the *opticus* extend downward between them to a layer of multipolar cells beneath. Below this layer of granular (osmic acid) ganglia cells, cylindrical and very regular hexagonal cells are found; the axis of each is situated in the direction of the entering light. These hexagonal cells are attached to the pigment-skin at the outer limit of the retina. Pigment granules extend up the sides of the partition walls of these hexagonal cells for some distance. The walls themselves are thickened below, and in this way concave spaces are formed, one at the bottom of each hexagonal cell. These spaces are completely surrounded by pigment.

In the centre of each a rod Stäbchen is situated. This has a conical shape, is attached with a broad base to the bottom of the concave space, and tapers rapidly at first, and more gradually afterwards to a fine point. Its faces appear concave. The upper pointed end of the rod is continued in the shape of a very fine thread, extending through the centre of the hexagonal cell and joining the ganglia cell-layer.

Nothing is to be added to Semper's statements regarding the *nervi optici*.

"It is remarkable that the *Onchidium dümellii* never retracts her tubercles or feelers, however near the forceps or scissors approach them, until they are actually in contact. This might lead one to assume that this animal is far-sighted. The concave lenses on the upper ends of the facets, below the large spherical main lens appear as a secondary arrangement produced for the purpose of counteracting the bad effect of an oval or spherical lens in air. The lens was originally, probably, adapted for seeing in water, and therefore had such a great curvature and short focus. When the *Onchidium* took to living on land this lens was too strong—for use in air,—and then the little concave cells might have been produced to counteract the excessive power of the main lens."

Having had the advantage of studying a fine series of sections of the Australian *Onchidium*, kindly made for me by Mr. Whitelegge, who made those studied by Dr. Lendenfeld, I am able to record my own observations on the eyes and the general anatomy of this most interesting species. In doing so I shall enter into the matter a little more fully, as I am sure that the observations of Dr. Semper are very little known in this country, or perhaps anywhere except in scientific circles.

It has been already remarked that *Onchidium* is a genus of Mollusca without any shell. On making a section through the skin, however, this is found not to be strictly true. The little papillæ which so thickly cover the surface with warty excrescences are, on the dorsal area, covered with a layer of little cavities, in all of which there is a much smaller brown limestone concretion. Inside the layer there are sometimes larger cavities, generally of an ovoid shape, in which there is also a rounded calcareous concretion. These are the otolith-like concretions. They are numerous and of relatively large size. In pl. vii., fig. 9, is represented a section through one of these layers of rudimentary shell, which is interesting for many reasons. First of all there is a layer of skin between the outer surface and the concretionary cells; and secondly these cavities have generally a rounded outline, while the calcareous matter is ragged and angular. Another point of interest is that some of these concretionary nodules extend far

into the muscular tissue, and do not lie immediately under the skin. The concretions are not connected in any way with the papillæ, because they seem to be as numerous in the grooves and depressions as where the skin is raised into warty tubercles. Some of the cavities are empty, but probably this happened in making the section.

The eyes may truly be described as assuming every shape. They are in pairs, in triplets, on stalks or rather warts, and in depressions. In pl. viii., fig. 11, there is a section through one of the less conspicuous warts on the side of the animal. It represents a double optical organ, the smaller one being a section close to the pigment cell, and the larger through a fully developed eye. In the section the rods can be seen enclosed in the fibrous layer of the retina.

In some of the eyes the radiating fibres of the optic nerve are interspersed with small cells. The peculiar plano-concave bodies, which are highly refractive, broad and cylindrical, between which the optic nerve extends downwards to a layer of cells below, were rarely seen in any of the eyes examined by me. If I am right in my identification of these bodies, noticed by Dr. Lendenfeld, they are only to be found in the most perfectly developed eyes. I did not succeed in isolating any of the rods, though an examination of the matter is still in hand. In pl. vii., fig. 10, I have given an illustration of two eyes wherein the rods are well shown, and an enlarged figure of one of them in fig. 12 will give a better idea not only of the relative positions of the retina and rods, but also of the peculiarities of the eyes themselves. In the upper eye of fig. 11, there is a slightly pinkish somewhat heart-shaped section of the lens. In the radiating fibres of the retina, the ganglia cell can be seen with the included refractive bodies at the point in fig. 12, marked *g c*. The axes of the hexagonal cells are not always in the direction of the entering light, but some of them are distinctly curved. At point *p c* in the enlarged fig. 12, pigment granules can be seen extending up the sides of the partition walls of the hexagonal cells. It will be seen also how the walls are thickened below and how there is a ganglion cell resting on the pigment cell. Two very large ganglionic cells are noticeable just below the optic nerve in the lower eye, fig. 11.

At pl. ix., fig. 13, there is a section given of a dorsal eye, showing the entry of the optic nerve passing through the rods and spreading out above them. In this section the cell-structure can be well seen. The section has been cut obliquely, and shows the enlargement of the nerve below the entry in a somewhat exaggerated form. The apertures in the pigment-coat below the rods, are possibly channels for the entry of the vessels of

circulation, as will be seen from the explanation presently to be given of another figure.

With reference to this section, it may be remarked that some of the strands of the optic nerve end abruptly after passing through the rods and project in fibres from the surface of the retina. These broken ends may have arisen in cutting the section, though that is not the appearance. The whole section gives a good idea of the nature and extent of the *blind spot* in the dorsal eyes of these small animals.

In pl. ix., fig. 14, we have a representation of a fragment of the basilar membrane and pigment-coat surrounding one of the dorsal eyes. This is taken from the outside of a large eye with a very thick circle. The larger perforations seem to be passages for circulating vessels; the smaller for nerves which proceed outside the eye to the cornea, argentea, &c. One cannot help remarking the strong resemblance this section has to a section of the basilar membrane of the eyes of insects, given by Mr. Hickson in his paper* "On the Eye and Optic Tract of Insects." His figure has reference to a portion of the basilar membrane of the eye of *Agrion bifurcatum*, and it shows much more regular perforations: the larger for the tracheal vessels and the smaller ones for the terminal optic fibrils. In the smaller perforations of my figure, the strands of the nerve-fibre can be seen. Moreover this section manifests the nature of the membrane which in section is seen to surround the pigment-coats; though the latter are so dark and impervious to light that any membrane is difficult to see. Of course it does not correspond with the basilar membrane of insect eyes, whose place is at the base of the ommatidia upon which they rest. The section is additionally interesting as affording an idea of the great number of nerves and circulating vessels which supply the outside of the eyes in these dorsal papillæ. The section is magnified about 200 diameters. The prolongation at the upper end of the fragment would seem to imply that the basilar membrane itself is colourless and only darkened by the pigment-coat.

EYES ON THE PERIOSTRACA.—In one form or another an investing membrane outside the shell is very universal throughout the Mollusca. In some it consists of the merest film; while in others it forms a conspicuous skin membrane, investing the shell and considerably altering its appearance. It is probable that this investiture is intimately connected with sense-organs, because we find such a very elaborate system of bristles and filaments as must have some connection with the feeling or hearing of the

* "On the Eye and Optic Tract of Insects," by Sydney J. Hickson, B.A., Quart. Journ. Microscop. Science for 1885, vol. xxv., p. 215, pl. 17, fig. 28.

animal. It is probable also, now that we know more of the economy of Mollusca, that we can assert that the tissue subserves the purposes of seeing as well, an instance of which I believe we have in Australia.

In Sydney Harbour *Triton spengleri*, Lam., is a common species, and it is conspicuous, like a good many of the Tritonidæ, for the possession of a very transparent yellow periostraca which invests the whole shell. It clothes this so closely as to follow every rib and grooving, and is in itself in fact a perfect reproduction of the whole surface. But it has organs which the shell has not. The membrane is thickly studded with long, sharp, curved points like teeth. These are doubtless organs of feeling, as they are seen to be connected with nerve-fibres of the utmost delicacy. Portions of this periostraca, submitted to microscopic examination, reveal certain organs so like the shell-eyes that one can scarcely refrain from classing them together. First of all there are transparent clusters of minute round vesicles, some with dots like pupils and some without them; all being refracted to some extent as if they were made of glass. Next there are clusters of what may be eyes about the same size, for they have a distinct outside ring of pigment and a pupil as well. Next there are small, black, rounded bodies sometimes gathered in clusters, and sometimes like little strings of beads. The centre of these little bodies is so highly refracted as to be quite brilliant. There is a pupil and an intensely black outside coat. These clusters are rather larger than the clusters of vesicles first spoken of. Finally there are large oval organs, five or six times larger than those already described, with only a faint pigment coat around the clear horny substance which encloses them. In one of these I was able to observe a structure something like the dorsal eyes of *Onchidium*, though the section was not quite satisfactory. There was apparently an optic nerve on the outside, and on the surface of this, the position being the reverse of that which is found in *Onchidium*, but corresponding with what Prof. Mosely found amongst the Chitonidæ. This, as already observed, is what is usual amongst the Mollusca. Fine nerve-fibres can be traced in connection with all these organs, showing the periostraca to be truly a portion of the living tissue as much as the skin of any other animal. Its points of attachment during life are with the mantle, where additions are made to its growth, and also most probably nerve-fibres reach it from the shell.

It cannot be absolutely asserted without further examination that these organs are eyes, though I do not see what else they can be. It shows us, however, what an important field for observation the periostraca may become. Amongst the highly coloured and ornamental shells such as the cones, this membrane

plays a very important part, and it is here that the dermal eyes must be looked for if they exist at all. This, however, is the part that is ruthlessly swept away by the shell collector, and a most important and interesting portion of the animal organism is destroyed. It is thus, as I have already stated, that the shell-eyes of the Mollusca have remained so long concealed from naturalists.

Cerithium ebeninum, Brug.—In the mantle of this species I have discovered curious rounded bodies having all the appearance of eyes enclosed in semilunar chambers, at the extreme edge of the mantle which is also studded with innumerable minute rounded bodies which refract the light very brightly. These larger bodies, possibly, are compound eyes, and together with the smaller bodies, are reserved for special examination. The whole of the mantle is interlaced with nerve-fibres and a few capillary channels. There is always a distinct and abundant nerve supply at the base of these mantle-eyes. Outside the thickened margin of the mantle there is an excessively thin membrane which stretches beyond it. (For figure of shell see pl. v., fig. 5.)

Acmea marmorata, Tenison-Woods.—Sense-organs in the form of little black dots surrounded by a darkened ring. Perhaps in the whole extent of a shell there may not be more than one or two such clusters containing about 20 eyes. (?)

Emarginula rugosa, Sowerby.—This species has prominent ribs which the transverse lines of growth divide into nodules of irregular size. The sense-organs are very numerous in some species, possibly on all, but they are so small that they are very difficult to see. Like all shells with a rough exterior, there is always an abundant growth of algæ and shelly parasites where of course the shell structure is destroyed.

Trochocochlea teniata, Q. & G.—Sense-organs very minute, in little darkened pits, crowded irregularly over the whole surface of the shell. Cornea (?) very brilliant and where the organs project a little it seems as if the shell were studded with gems. Underneath the tegmentum of this shell, the next shell-plate is completely black and apparently full of little foramina for the passage of nerves and blood-vessels.

Venus paucilamellata, Dunker.—This is a somewhat common, thick, opaque shell, about $1\frac{1}{2}$ inches in transverse diameter. The substance is very opaque and only permits the structure to be seen in the thinnest sections, and then indistinctly. The surface is covered at intervals, not entirely, with sense-organs, forming a close pavement of minute capsules, so small as to make it impossible to see their structure unless with very high magnifying powers. The capsules, however, contain nerves. This species can only be examined to advantage in the freshest specimens. The calcareous

structure is so hard and compact and the sense-organs so fragile that they are rubbed off very easily. If at any time the valves are completely covered with an eye-pavement, then it is impossible to calculate what numbers there are as they are so small, but I have good reason for believing that they never do completely cover the shell.

Cytherea sp. ?—The shell here referred to, has a highly enamelled shining tegmentum, but is from Japan and not Australian. The outer layer of shelly matter is of a rich brown colour and full of small tubes which are abundantly supplied with nerves. Having a section of this shell, I introduce it as an instance of a highly enamelled shell with a brilliant polish on the tegmentum which would seem incompatible with the sense-organs. Yet sense-organs do exist even on this enamelled shell, and there is a large nerve-ganglion, but I have not been able to detect the eyes as yet.

Elenchus bellulus, Phil.—This shell belongs to a well-known group distinguished by their richly iridescent nacre. The outer plate of the shell is hard and compact, and sense-organs appear to be present.

Trochus (Calcar) tentoriiformis, Jonas. (Zeitschrift für Malak., p. 66, 1845.) This remarkable shell is found abundantly in Port Jackson underneath the ledges of rocks at low water spring tide. The shape is very peculiar in one particular, that is the deep concavity of the base whence the name of tent-shaped no doubt has been derived. Mr. J. Brazier has drawn my attention to another peculiarity, that is the many radiating grooves on the lower whorls of the young shells, which make it resemble in some respects *Trochus imperialis* of New Zealand, or *T. costulatum*, Lam. In the adult species, however, the shell is so very much corroded and encrusted, that these grooves disappear, and then the spire is high and acute. The normal surface of the whorls is covered with a series of very finely imbricated lines of growth, much undulating and sometimes irregularly crossing or uniting with each other. Under the microscope these lines appear to be studded near the base with minute refractive lenses in great numbers, occupying for the most part the hollows between the lines. The shell is highly nacreous and apparently easily corroded. On the base about half the surface is covered with finely divided spiral lines or ribs equal to each other and regular. These are crossed by very fine raised undulating shelly plates or imbricated lines, grooved on the upper edge, and within this groove there are the openings of what appear to be capsules and possibly sense-organs, but of which a careful examination has not been made. At pl. xii., fig. 19, there is a vertical section of the columella of this shell, which in many respects seems to be one of the greatest interest, but which as yet has only been partially examined.

Nerita atrata, Reeve = *N. saturata*, Hutton = *N. melanotragus*, E. A. Smith = *N. punctata*, Quoy, followed by Watson. (Voy. "Challenger," XV., 132.)* This shell appears to be equally common on all the south coast of Australia, and on the south-east, as far at least as Newcastle. It is a very hardy animal, as I can testify that it bears change from salt to fresh water without apparent injury; but as a rule does not like water of any kind, for it generally keeps out of it as much as possible. It has an almost smooth black tegmentum with small white indistinct spots, and is spirally grooved. On these grooves there are occasional pits or depressions, and in these still more rarely there are minute white eyes with a black dot or pupil in the centre. These are easily seen with a somewhat powerful lens, because of the contrast they make with the black tegmentum. But I have met so many individuals in which there were no eyes, while in all they are of such rarity and so easily destroyed, that I quite hesitate to record them. On young shells, however, and near the margin of the aperture in full-grown specimens, the tegmentum takes the form of a much wrinkled periostraca, the wrinkles being parallel with the aperture, and crossed at regular intervals with very fine

*For some years past I have been accustomed to quote this shell under Reeve's name, for which some explanation is necessary, and I cannot do better than give here the words of Mr. Tryon in his "Manual of Conchology." (Vol. x., p. 26, pl. viii., fig. 40.) "Reeve figured this species for *N. atrata*, Chemnitz—which it probably is not, and on this account von Martens preferred for it the name *N. punctata*, Quoy—which it certainly is not, whilst Hutton imposed the name of *N. saturata*, and E. A. Smith that of *N. melanotragus*, both in 1884 with a probable priority of publication of the former name. Watson (Voy. "Challenger," XV., 132) reviews the whole subject, preferring the name *N. punctata*. Inasmuch as Chemnitz was not binomial, and therefore not entitled to quotation, and his figures and descriptions are neither of them sufficient for identification, whilst they indicate that at least two species were confounded by him, I think it preferable to treat him as non-existent, and quote Reeve, especially as he has been followed by others so that *his atrata* has become well known. *N. nigra*, Gray (who quotes Quoy), in "Dieffenbach's New Zealand," has been cited by authors as applying to the present species, but the name is not accepted by them on account of the prior *N. nigra*, Chemn. They show that Quoy never described a *N. nigra*, but then neither did Gray; he merely mentioned the name in his above list, and it is impossible to determine what species he may have intended. Finally, different as this species is from *N. nigerrima*, Chemn., in its form and absence of columellar granulations—actually a group distinction, I have nevertheless some suspicion that it is only a variety of it, and that it connects that species with *N. morio*, which, on account of its smooth inner surface of the lip belongs still to another group. In my saner moments, I am well aware that such vagaries of conjecture are simply the demoralizing result of the questionable questioning which has largely supplanted the questionless faith of the last generation of conchologists." The only thing I have to add to this quotation is that the columella of adult shells is slightly granular.

L—July 4, 1888.

depressed lines. Now this portion of the species is covered with innumerable highly refractive dots and points, and with bodies which appear like protruding sense-organs, somewhat similar to the knobs already described on the outer surface of *Trigonia*. On the very outer edge of the peristome the lenses are symmetrically arranged in rows, and altogether this is the best part of the shell on which these organs are displayed. They are very minute and exceedingly numerous, though they are separated by an interval of thrice their own diameter.

Like many of the genus the operculum is studded with small transparent warts or protuberances, much larger than anything in the shape of eyes. In the species now referred to they are numerous, gradually increasing in size from the nucleus to the margin, being largest and fewest at the opening of the spiral corresponding to the aperture. The whole surface of these is seen under the microscope to be covered with small hyaline lenses, or else the exit for sense-organs. Some of the eyes in the midst of these bosses are of large size. A section through the operculum shows that every one of these protuberances is supplied with nerve branches contained in a capsule or sheath. It is probable that the glassy granules on so many of the operculums and columellas in this genus are connected as in this species with visual organs.

DEVELOPMENT AND LIFE-HISTORY.—The study of the life-history of Australian Mollusca cannot be expected to present any remarkable deviations from the usual types. A few years ago nothing was known about their development except in a very few instances, and as yet a better state of things has not extended to Australia. The reason for this need hardly be explained. The difficulties connected with observations on such matters, though very much exaggerated, are enough to deter most naturalists; besides the great work of collecting and cataloguing the species we possess, is so far from being finished, that it absorbs all the energies of our zoologists, and gives them no time for the arduous and intricate researches of histology.

Nevertheless something has been done, though it is but little, and before long it is to be hoped that a good deal of special and interesting discovery in these matters will see the light. In this essay I have so little to offer that it is only with extreme diffidence I place on record the following few scattered observations.

As already stated the variation in the development between different species is but slight, but still there is some difference, and this will be an incentive to our biologists. As an instance of this I may relate what I have observed amongst the oysters. There is no difficulty of obtaining material for observing the ova of this Mollusk. The ova of all the Lamellibranchiata are developed in

pouches of the ovary which are lined by flattened germinal epithelium. These cells or rather some of them, enlarge and become ova, remaining attached to the walls of the pouch by stalks. At this stalk there is a perforation of the investing membrane, in some species at least, which becomes micropyle.

The function of this is to assist in the nutrition of the ovum during its development. The eggs of the Lamellibranchiata are not only remarkable in the possession of a micropyle, but in certain peculiarities of the yolk and of the germinal vesicle. The technicalities of this portion of the subject it is impossible for me to enter upon. There is however one part of the history of development where observations can easily be made. When the ovum has been fertilized, the immediate result is its segmentation or the division of the ovum successively into two, four, eight, &c. successive parts. Where this is equal, it is called regular segmentation. In Mollusca however, unless in rare instances, segmentation goes on unequally. The ovum divides into two and then four unequal segments in the usual vertical planes. In the third segmentation four small segments are budded off from the large ones; so that there are four small ones in one plane and four large ones in the other. Without following the process to detail, it may be said that unequal segmentation for the ova is the most widely distributed in the animal kingdom, and for Mollusca except Cephalopoda it is typical.

Passing on to the larva stage, there is what is called amongst Gastropods the veliger stage, when on the surface of the shell-gland a delicate shell becomes developed. In the Lamellibranchiata the veliger stage presents the larva with a ring of cilia, and in the centre a long flagellum. This stage I have often seen in the case of our common rock oyster (*Ostrea mordax*, Gould). It is not very difficult to witness the whole development of the oyster. Let a female oyster be taken and some of the milt of the male mixed. It is not long before the ova are developed. By the aid of warmth and favourable circumstances eggs may be hatched in two hours. About twelve hours after the free-swimming stage the shells begin to appear with the germs of other organs. The shells are distinct from the first, and for a long time have a smooth rounded outline. At the end of six days the shells nearly cover the embryo, which is hardly more than visible to the unassisted eye as the merest grain. All the larger organs can be seen with a microscope, as they are then separated, with the exception of course of the reproductive tissues such as ovary and milt. After swimming about in this stage for a few days, the period of which has not been exactly ascertained, the young oyster, the so-called "spat," fastens itself by one valve of its shell to any rough and clean body. It is then very thin and delicate,

but grows fast. If it has not some object to fasten to, it sinks to the bottom. There it may find the living and dead shells of its relatives, or a rock or other shells, and there it will grow. It is not uncommon to find nearly a hundred small "spat" on one oyster shell. It is then that oyster cultivators collect them and lay them in convenient places to fatten. Without artificial assistance there can be no doubt that the great mass of oyster ova perish.

Many observers have asserted that the ova are fertilized within the ovary, and are afterwards nursed in the folds of the mantle. Dr. Brooks has proved that this is not true of the American oyster (*O. virginiana*).^{*} Up to a very recent period all my observations tended to confirm this. In my "Fish and Fisheries of New South Wales," published in 1882, I wrote as follows (p. 114):—"I have carefully examined many ripe female oysters, and never could find any embryos on the mantle. It is probable that the egg is discharged into the water to be fertilized, where in oyster-beds and amidst its own species it easily may meet with a male cell. If, however, it does not meet with such, the ova are rapidly destroyed by sea water."

In these observations I am now convinced that I have been completely wrong, and I hasten to correct the erroneous conclusions founded on them. My error arose from the kind of oysters I selected for experiment being those in which the ova was barely ripe, with no young oysters in them except those which had been obtained by artificial fertilization. Recently the experiments were renewed, and investigations made upon oysters in which the ovary seemed nearly empty. On submitting the gills of these to microscopic examination, I found in the openings between the filaments where the water comes into more immediate contact with the blood, a number of young oysters, in fact in the same position in which the young embryos are found in the *Unio* or freshwater mussel. The whole of this portion of the branchial filaments is richly furnished with cilia which keeps up a visible current in the openings. In these the young oysters may be seen hurried to and fro by the current, in every stage of development. The majority had their shells, if not forming a complete valvular investment, at least in an advanced state of development. Only a few larvæ in the veliger stage were perceived. The sight is a most beautiful and interesting one, and may be witnessed for fully half-an-hour after the animal is dead.

The life-history therefore of the Australian oyster is this. When the ova have been fertilized they are segmented with

^{*}"Development of the American Oyster," by Dr. W. Brooks, p. 15. Printed as an Appendix to the Report of the Commissioners of Fisheries of Maryland, January, 1880, Annapolis, State Printers, 1880.

unequal segmentation, and the small segments gradually envelope the large hypoblast spheres. Then one side of the embryo is flattened and it becomes covered with short cilia, which causes it to rotate within the egg-capsule. The shell subsequently appears as a double organ. The two valves grow very fast and cover the larva, in which mantle-flaps begin to be perceived. This is the stage when the ovum is hatched, and the young are carried down by the currents into the gill-chamber, where they become developed and the shell rapidly forms so as completely to cover them. The time when the nursing of the mother ceases I have been unable to ascertain, but I believe that it is sufficiently developed to be able to affix itself as "spat."

These observations may have a certain value, for it points to the value of the mother-oysters as nurses, which may influence the methods of preservation. In any case it will be interesting to observe that young oysters are reared in the gill-chambers of the mother, in the case of the Australian oyster (*Ostrea mordax*, Gould). Of course this does not affect the question of the American oyster. In the case of that species it has been over and over again affirmed that the American oysters rear their young in the gill-chambers like the freshwater mussels. This on the other hand has been over and over again denied by high authorities. The question cannot yet be said to be set at rest.

Now with regard to *Unio* the question is one of great interest, for we have many widely distributed species in Australia, all differing in only the slightest possible details from European or American species. The peculiar interest which attaches to the freshwater mussel, however, is this—that the eggs are retained within the gill-chamber of the female mussel through all the earlier stages of development. When the young mussel escapes from the egg, moreover, it is so unlike a mussel that its relationship was never suspected. It has hooks to attach itself, which it does promptly, to the tails of fishes, where it was found and thought to be a parasite, and named *Glochidium*. This larva possesses a bivalve shell on which are the hooks above mentioned. The mantle can also be discerned, and an adductor muscle for closing the shell when required. When the larva is swept out from the body of the parent, and becomes anchored as already stated, it grows rapidly, and as it does so becomes more and more like the well-known freshwater mussel.

The various changes to which the mussel ova are subject have been observed and described by many different microscopists, amongst whom there is still considerable difference of opinion. Without attempting to follow these technical details, one or two points may be given as throwing light on what has to be observed in Australia. The development of the velum from the ovum

need not be described. When this change has taken place the shell is formed as a continued saddle-shaped plate on the dorsal surface, where subsequently the two valves become separated. They are at first rounded but become triangular, and an avicular or bird's-beak organ is formed at the top of each valve. It has serrations at its edge which aid in affixing it as a parasite. More than this from actual observation cannot be said. In the European *Unio*, after the shell is formed, a new structure makes its appearance which is known as the byssus gland. The following is what succeeds, according to Rabl as given by Balfour*:—Before the mantle are fully-formed peculiar sense-organs, usually four in number, making their appearance on each lobe. Each of them consists of a columnar cell, bearing at its free end a cuticle from which numerous fine bristles proceed. Covering the cell and the parts adjoining is a delicate membrane, perforated for the passage of the bristles. The largest and first formed of these organs is placed near the anterior and dorsal part of the mantle. These organs probably have the function of enabling the larva to detect the passage of a fish in its vicinity, and to assist it therefore in attaching itself. With the development of the shell, the mantle, and the sense-organs, the young mussel reaches its full larval development, and is now known as a *Glochidium*.

If the parent with *Glochidia* in its gills, is placed in a tank with fish, it very soon (as I have found from numerous experiments) ejects the larvæ from its gills, and as soon as this occurs the larvæ become free from the egg-membrane, attach themselves by the byssus cord, and when suspended in this position continually close and open their shells by the contraction of the adductor muscle. If the mussels are not placed in a tank with fish the larvæ may remain for a long time in the gills.

Acmura septiformis Q. & G.—In this case the ova form no exception to what I have observed in *Ostrea* and what has been generally seen amongst the Mollusca. In dissecting away some of the gill-plumes I have found the eggs associated with the branchial apparatus. They are round lenticular vesicles of somewhat dark leaden grey colour containing the partly developed embryo, in which I have never been able to make out clearly more than a highly crystalline oval mass, filling about one-third of the membrane, which is possibly the differentiation of the shell. The eggs thickly surround the gill-plume, but are not, except in a few instances, within the margin of the plates. In the plume there is, properly speaking, no gill-chamber, as in the Lamellibranchiata. The filaments are long and narrow, and the

C. Rabl, "Ueber d. Entwicklungsgeschichte d. Malermuschel," *Jenaische Zeitschrift*, Vol. X., 1876.

chitinous rods apparently closely united. There is nowhere any aperture large enough to receive one of these eggs, which surround the plume usually in numbers between 200 and 300.

Siphonaria diemenensis, Q. & G.—The development of the ova in this species is attended with considerable interest, because there is a pulmonary sac in which a gill-plume is contained. I have never observed the ova in the sac, but I have reason to believe that they are developed there. Its position is different from the branchial chamber of the species just described, for the sac is at the middle of the right side, whereas in the genera referred to it is at the back of the head. Into the latter arrangement the ovary opens, and so it does in the pulmonary chamber, at least I think I have observed such a passage, but this requires further investigation.

As a rule, in the Gastropods, the ovary discharges into a much looped oviduct, and opens finally into the respiratory cavity. I have been able to examine a newly hatched specimen of the species at the head of this article. The shell was perfectly formed, at least was complete in its conical covering to the foot of the animal. The intestinal tube was partially developed. At the opening which represented the commencement of the mantle cavity around the head, there was a lobe of the mantle studded with from 80 to 90 minute highly refractive round bodies like lenses. At some distance behind this was the Radula already differentiated to its whole extent, and curving round in the position in which it was always found in the adult state. The line of division down the centre was distinct, and the plates with minute teeth passing to each side gradually diminishing in size to the edge. The pulmonary sac and the unformed branchiæ could be traced as a series of fine filaments attached to a central rachis. The whole of the mantle was studded with minute hyaline cells of crystalline brilliancy. The liver is distinguished as a mass of brown pigment. The kidney is distinguished as a mass of highly refractive calcareous matter which, with the polariscope, shows curious semi-crystals of yellow and brownish colour. The heart is differentiated and a portion of the aorta can be traced.

SUMMARY.—The following is an epitome of the facts to which attention is drawn in the preceding essay :—

1. Australia is entitled to be considered as a true Molluscan province with peculiar features, and yet not separated in an extraordinary way from Molluscan provinces elsewhere.

2. The "Australian" characters are more strongly manifested in proportion as the coast-line is followed to the south.

3. There are few, if any, species common to Australian and European seas.

4. The tropical fauna of the Indian Ocean is extended in many respects far into the extra-tropical portions of the Australian seas.

5. An examination into some of the principal organs of the Mollusca, such as the Radula, branchial arrangements, &c., shows that they possess the features which are common to Mollusca all over the world.

6. The circulatory organs are also the same with hæmoglobin uniformly in the circulating fluid in the same portions of the animal. The genera *Arca* and *Solen* and probably *Fasciolaria*, have species with red blood as in Europe.

7. The sense organs in the tegmentum of the shell, which were first discovered by Prof. Mosely in several genera of Chitonidæ, are found in many genera of both bivalves and univalves, such as *Trigonia*, *Anatina*, *Arca*, *Pecten*, *Venus*, *Ostrea*, *Patella*, *Acmaea*, *Siphonaria*, *Cerithium*, *Turbo*, *Littorina*, *Risella*, and others.

8. In two species of *Trigonia* the development of the eyes strongly resembles that of the Ommatidia of insects, associated with sense-organs forming probably the most interesting and wonderful instances of this peculiar endowment.

9. Associated with these sense-organs large ganglia and dependent nerves are found in the substance of the shell in both univalves and bivalves.

10. The calcareous opercula of some species contain nerve-ganglia and sense-organs, and probably this is shared by some chitinous opercula to a small extent.

11. The ganglia in the shell-substance are so much larger than any nervous tissue in the softer parts of the animal, that they are apparently the main sources of nervous influence.

12. That these ganglia suggest from their position and their multiplicity of sense-organs, that they are really cerebral ganglia.

13. That the above bivalve species are erroneously described to be acephalous, and that if anything they are better endowed with a head and brain structure than some univalves.

14. In the mantles of both bivalves and univalves eyes have been found, as well as on the dorsal papillæ of some species of *Onchidium*.

15. In following the life-history of young oysters, it is found that the ova are nursed in the gill-chambers of the parent, a fact which may have an important influence upon their cultivation.

16. A similar arrangement is found to exist among certain species of *Unio*, *Siphonaria*, *Patella*, and *Acmaea*.

17. In very young *Siphonaria*, but sufficiently advanced to have all the organs differentiated, the lobe of the mantle in front of the head is found to be covered with from 80 to 90 minute spherical and highly refractive bodies which seem to be sense-organs and may have visual powers.

EXPLANATION OF PLATES.

Plate iii., fig. 1.—Enlarged figure of *Patella tramoserica*, Martyn, magnified about eight diameters. The eyes are represented on three of the ribs only, but the sketch is an ideal one. On the whole the eyes are not so uniform in size or so closely placed as they are represented at the base of the central rib.

Plate iii., fig. 2.—Portion of Radula of *Patella tramoserica*, Martyn, magnified 50 diameters. The teeth are in pairs with a strong angular projection on the outer side. They are bent down near the point of attachment to the chitinous membrane of the Radula. These teeth are hollow and of dark brown colour. No distinction in the form of the teeth seems to exist among a great many species of *Patella*.

Plate iv., fig. 3.—Radula of *Acmæa septiformis*, Q. & G.—In this case the plan of the Radula which is similar to that of *Patella* consists of teeth like *Patella* in alternate pairs, two or four in the middle and one or two at each side. It is not nearly so long as in *Patella*, being very little longer than the animal, and the teeth are small. In the figure the teeth are not so well seen owing to the partial investiture of the tube in which they are all sheathed. It is not curved to the same extent in the animal. The portion represented is opposite to the buccal end, and the teeth are in consequence more glassy and transparent.

Plate iv., fig. 4.—Portion of Radula of *Cerithium ebeninum*, Bruguière. The type of this Radula is that of a Siphonostomata of the order Pectinibranchiata, sub-order Tænioglossa, group Rostrifera. The teeth are few in number with a short Radula having a broad central tooth overlaid with a number of sickle-like lateral teeth.

Plate v., fig. 5.—Back and front view of *Cerithium ebeninum* Brug.

Plate v., fig. 6.—Tentacle eye of *Cerithium ebeninum*, Brug., showing two small subsidiary eyes on the choroid coat, and one on the cornea. *a* and *b* choroid eyes, *c* eye on cornea.

Plate vi., fig. 7.—Another tentacle eye of *Cerithium* or *Triton*, genus uncertain, with faceted structure.

Plate vi., fig. 8.—Shell-eye of *Patella tramoserica*, Martyn. From the edge of the peristome obtained in a section of the shell, *a* optic nerve, *b* branch proceeding to upper portion of eye, *c* choroid coat, *d* retina, tapetum and rods.

Plate vii., fig. 9.—Portion of the dorsal mantle of *Onchidium dämellii*, showing cells containing partially formed shelly matter, *a* fragments of carbonate of lime in cells. $\times 75$ diam.

Plate vii., fig. 10.—Pair of dorsal eyes *Onchidium dämeli*: *a* a pigment-cells, *b* refractive, hyaline bodies on rods, *c* rods, *d* optic nerve on the inner ends of rods, *e* probably pigment membrane of third eye removed in making section.

Plate viii., fig. 11.—Small double eye from dorsal eyes of *Onchidium dämeli*, *a* pigment coat, *b* rods, *c* optic nerve, *d* pigment-coat with entrance of optic nerve, *e* passage of a branch of the optic nerve into larger eye apparently connected with the smaller eye, but this is probably due to the way in which the section is cut.

Plate viii., fig. 12.—Dorsal eye of *Onchidium dämeli* highly magnified, showing structure of rods, *p c* pigment-coat, *r* rods, *g c* ganglion cell with refractive bodies, *o n* optic nerve. $\times 200$ diam.

Plate ix., fig. 13.—Dorsal eye of *Onchidium dämeli*, showing optic nerve, *a* optic nerve, passing through rods, *b* abrupt terminal endings of nerve fibres on inner surface of rods, *c* foramina in basilar membrane and pigment-cells, *d* cells at base of rods, *e* basilar membrane.

Plate ix., fig. 14.—Basilar membrane of dorsal eye *Onchidium dämeli*, *a* foramen for passage of nerve branches, *b* probably foramina for vessels of circulation. $\times 400$ diam.

Plate x., fig. 15.—Section of an eye of embryo *Octopus* in egg; *a* cornea or integument, *b* iris, *c* ciliary body, *d* aqueous chamber, *e* internal rods of the retina, *f* pigment-layer, *g* external layer of rods, *h* body of optic ganglion, *i i* white bodies, *j j* lens.

Plate x., fig. 16.—Section of three ribs of *Trigonia lamarckii*, Gray, *a* tegmentum showing pavement of eye-capsules, *b* stratum of sheaths or tubes leading up to capsule, *c* strands of nerve fibre between capsules and ganglion, *d* ganglion supplying capsules of ribs, *e* ganglion or mass of nerve-sheaths in nacreous layer, in which the nerves terminate.

Plate xi., fig. 17.—Nerve ganglion or mass of nervous matter in nacreous layer of *Trigonia lamarckii*, Gray, *a* plate of membranous tubes, *b* nerve ganglion in nacreous layer.

Plate xi., fig. 18.—*Trigonia margaritacea*, Lam., *a* tegmentum eye-capsules, *b* ganglionic mass with fibres and cells, *c* nerve-fibres in nacreous layer.

Plate xii., fig. 19.—*Trochus (Uvanilla) tentoriiformis*, *a* nerve ganglia, two in number cut at different parts of the spire of columella, *b* nerve-sheaths.

Plate xiii., figs. 20, 21.—Exterior of right and left valve *Trigonia lamarckii*.

Plate xiii., fig. 22.—Interior of valve of *Trigonia lamarckii*.

Plate xiii., fig. 23.—Interior of valve of *Trigonia margaritacea*.

Plate xiii., fig. 24.—Exterior of valve of *Trigonia margaritacea*.

Plate xiv., fig. 25.—Outer surface of *Trigonia lamarckii*, seen obliquely. $\times 300$ diam.

Plate xiv., fig. 26.—Surface of a tubercle on ribs of *Trigonia lamarckii*, seen obliquely, showing lenses. $\times 600$ diam.

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CONSIDERATIONS OF PHYTOGRAPHIC EXPRESSIONS AND ARRANGEMENTS;

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THE issue of a work on Victorian plants according to Lamarck's dichotomous method gave rise to this treatise. It seemed desirable to discuss the merits of his mode of dealing with plants for descriptive purposes, more especially so, as this kind of analysis has come but slightly into use during the century. Moreover the opportunity appeared to be an apt one for introducing to more general notice some views on the affinity and organography of plants, held for a long while by the writer, but to which fullest practical expressions have now only been given in the work indicated. It is the "Key to the system of Victorian Plants," to which is referred—the elaboration of which is just drawing to its end.

In the first edition of Lamarck's *Flore Française* (1778, in three volumes) the dichotomous characteristics for the main-divisions were partly derived from the Jussieuan system, though the latter was in full detail only published eleven years later, and partly from the Linnean system. In this manner the "fleurs uni ou bisexuelles," and the "dix étamines ou moins" and "onze étamines ou plus" are notes, obtained from Linné's classification, while the "fleurs pétalées ou non-pétalées," the "ovaire dans la corolle ou sous la corolle," the "fleurs complètes ou incomplètes," the "corolla monopétale ou polypétale," the "corolla régulière ou irrégulière" indicate already a preponderance of arrangement according to Jussieu's principles; but these very characteristics, offered by Jussieu, were devised already but less strictly applied by Tournefort, who again relied to some extent on earlier authors. Yet the sequence of the genera in Lamarck's work is often not according to real affinity, inasmuch as for instance *Clematis* stands far apart from *Ranunculus*, and (irrespective of others) *Potamogeton* and *Juncus* are placed between them. The numbering of the species is kept distinct.

Blindness having brought Lamarck's labours prematurely to a close, the great De Candolle in the early part of his luminous path issued, 1804, a third edition, in four volumes, the second edition, published in 1793 during a time of the worst political commotions, being probably only a reprint. This time the dichotomous analysis became applied only to the first volume, in which out of piety to his preceptor and friend the artificial arrangement was maintained by De Candolle, but for orders and genera only, so that still Mono- and Di-cotyledonous plants were to some extent mixed; the II., III. and IV. volumes however are without any dichotomy, and gave the full descriptions of the Flora of France, entirely according to Jussieu's system, which indeed is followed also already for the species in the first volume, thereby necessitating an independent numbering. When in 1815 a reprint of the work appeared, De Candolle furnished a supplemental volume, which embraced the plants discovered during the intervening ten years; in this additional volume the dichotomy is abandoned also. Lamarck in the original edition followed up each of the dichotomic notes immediately by some descriptive details, precisely as has been deemed proper for the "Key to the system of Victorian Flora," although his work could not exercise here any timely influence, it being now very rare, and could with De Candolle's later edition only be secured for us here a few months ago, after the printing of the whole dichotomy of the Victorian orders, genera and many of the species had already been done. It was the Lamarckian analytic method, which became attractive to the logic-minded Bentham during his stay in France; indeed it drew this

distinguished and laborious phytographer about seventy years ago into his illustrious career. Nevertheless he never applied this system of dualism to any of his writings, except the "Analytic Key to the natural orders and anomalous genera" of his "Handbook of the British Flora," that analysis extending over eleven pages; but the mode adopted involved some repetitions and in no way adhered to systematic sequence.

According to Lamarck's method hitherto only two works, elaborated in the English language, have become accessible here; both quite small and both of recent date, one issued by Dr. W. Marshall Watts in 1878, "a School Flora for elementary botanical classes," as indicated by B. D. Jackson's excellent "Guide to Botanic literature." Of the particulars of this work I was not aware until some months ago, when the second edition, published last year, was reviewed by the accomplished Mr. James Britten in his "Journal of Botany;" a copy of this edition reached me here only this month. It is intended for any students, "who have mastered the elements of botanic science," and is purposely kept very brief, to serve mainly for quick reference during a "country ramble," it being understood, that for home-studies could be consulted any of the numerous works on the British Flora, which appeared since Hudson's time, and among which Sir Jos. Hooker's Student's Flora and Babington's Manual—both particularly excellent—are brought up to recent date. For its purpose the work is as a whole well carried out; but it would be too abridged as a sole source for information; moreover it omits for briefness' sake many of the rarer plants, so that the number of the species treated does not exceed 900,—few immigrated plants being admitted. Nevertheless the little book is sure to render good services in its own way, which would be greater still if some illustrations could be added; a particularly gratifying feature in this work is the strict adherence to systematic sequence at least for species. The second work, alluded to above, is the "Handbook of the Plants of Tasmania" by the late Rev. W. W. Spicer, published also in 1878, and resulting from his two years' stay at Hobart, where the accumulated material of Gunn, Milligan and Archer was at the reverend gentleman's disposal, who based his compilation on the large "Flora Tasmaniae" by Sir Joseph Hooker, which resulted as one of the collateral achievements of Sir James Ross's Antarctic Expedition. Newer observations were obtained for Spicer's Handbook partly from works of the great George Bentham, and partly from volumes of the writer of this essay. This literary gift is all the more to be appreciated, as it was that of an invalid, whom search for health brought to these far southern shores. Deducting introduced plants, the number of species, treated by Mr. Spicer, is nearly a thousand,

therefore about half that occurring as indigenous in the colony of Victoria, but nearly equal to that of Britain. The genial author did not feel constrained, to adhere for the dichotomous disposal of the orders of plants to any natural system, but adopted for genera and species the Candollean arrangement. The numbering is consecutive throughout, therefore perspicuous and facile. His inexpensive book should prove even useful beyond the colony for which it was written, as for instance the vegetation of the southern regions of Victoria very extensively repeats that of Tasmania. As regards the utilisation of Lamarck's analytic method for any large floral region beyond France on the European Continent, I am only acquainted with the first edition of G. Lorinser's "Botanisches Excursions Buch für die Deutsch-Oesterreichischen Kron-Laender," published in 1854; but two more editions were issued, the last in 1871. Much erudition is displayed in this work, destined for use on botanic excursions. The orders are disposed of without any particular adherence to systematic arrangements, but in setting out the genera and species Prof. Lorinser also follows strictly the system of De Candolle; the numbering is not continued uninterruptedly, the species always following at once the genera in each order. For its objects, this neat and handy book must have proved of great value within the countries for which it is furnished, it being understood that for home-studies larger works were to be consulted variously extant there; the dichotomy is however not limited to solitary characteristics, and this militates against obtaining quick results; nor are the brief definitions supported by further descriptive notes, for guarding against possible misapprehensions. Cuerie's "Anleitung die Pflanzen des mittleren und nördlichen Deutschlands zu bestimmen," is another work for which the dichotomy was utilized; it went from 1823 till 1878 through thirteen editions partly by the later aid of Lueben and Buchenau.

The most recent work elaborated according to the Lamarckian plan, is the "Flore du Nord de la France et de la Belgique" by Bonnier and De Layens. Here again the sequence of the orders is independent of natural classification, the rigorous adoption of the dichotomy for the "familles" being particularly difficult. As no numbering is resorted to, the species could follow in systematic sequence at once after each genus; in using two pages always together, space is gained for ample schemata; more than one criterion being generally used for the dichotomic phrases, further descriptive details are dispensed with. But what renders the work unique, is the intercalation of over 2,000 small figures of single organs, for purposes of distinction, such as are in each case most decisive, so that a mere glance at the figures will often render it unnecessary to look at the text at all.

Besides a few limited local "Floras" exist for portions of the English and German and perhaps other countries, but they cannot be referred to critically on this occasion, as these small works are not accessible here.

The advantages of using a simple dichotomy are, to trace out quickly the name of any plant irrespective of gaining thereby any fuller direct knowledge of its characteristics—further to render thus far any lengthened study of marks of distinction unnecessary; the disadvantages are the scattering of the characteristics, the loss of view over their complex, the difficulty of seizing again the thread of affinity if once lost, and the rupture of the chain of natural affinity. It has on this occasion been endeavoured to secure all the advantages of the plan and to remove all the disadvantages.

The great difficulty of the method consists in singling out successively solitary, invariable and very obvious marks of distinction, by which one order or one genus or one species can be surely separated after another, until positions—always in a dual contrast—are exhaustively provided for all of them; and further to effect this uninterruptedly and yet systematically; whereas in ordinary treatment of plants, and indeed also of animals for descriptive Floras and Faunas, several cardinal notes are put together diagnostically, just as in medical science the complex of the symptoms gives the diagnosis of the disease, any single one possibly masked, though perhaps only exceptionally so.

In elaborating here such a plan of dichotomy, it became necessary, to construct for the complex of orders, of genera and also of species, whenever numerous, a tabular arrangement, somewhat like genealogic scales, so as to render the conspect easy at a glance; it is contemplated, to issue these tables hereafter in an Atlas form, according to a design adopted by Meissner for his "*Plantarum vascularium genera*," (1836 – 1840). The expediency of using a mere negative or some evasive expression or any general positive is never resorted to in the work now offered, for overcoming any difficulty in pairing off the main-passages, which to effect clearly and contrastingly is the real gist of the whole method; while its principal success must be sought in avoiding, that the species of plants and also their genera and orders do not become scattered regardless of natural alliance in perhaps a chaotic manner, that propositions are chosen which do not combine the utmost brevity also with logical comprehensiveness, and that the dichotomic notes, which are to carry over to the next passus, are wanting in obviousness and perfect reliability.

The organographic expressions, which we use at the present time, originated already—though only to a very small extent—with the ancients, who however did not even apply the terms always in the present interpretations; these terms were somewhat

augmented by mediæval writers, became enlarged and systematized by Joachim Jung early in the 17th century, got further improved especially also by Ray and by Linnæus, and since were variously changed and augmented, to meet gradually the requirements of later researches. In endeavouring to effect a few more alterations, I may first assert, that for nearly 50 years I experienced difficulties, to draw descriptively clear distinctions between the terms ribs, nerves and veins as used in botanic language, leaving some other anomalies in our modes of phytography just now out of consideration; and as the present work was to be written for a young colony, where time-honoured customs and usages also in botanic science have hardly yet exercised any influence, or are at all events not yet firmly established, it seemed to the writer very opportune, to effect in the work, now under discussion, the organographic alterations, which he so long had contemplated. Further it was felt by him, that the botanic language needed simplification, so that the use of two or more words for the same organ should be abolished, and that thus the task should be eased for any commencing learner without subsequent necessity to unlearn. Then again he held the view for a long while, that the descriptive terms, used in phytography, should not be identical with those employed in human anatomy and in zoology; to effect all this it required thoroughness, and it was ventured therefore, though only tentatively, to apply the proposed changes all at once to the volume indicated; while the new wording should in every instance be as clear as the former or even more so, though some sacrifice of brevity might be involved. The utility of the book itself could by the adopted alterations not be impaired even to the slightest extent.

To commence then, it became imperative to find a word, applicable to the whole fibro-vascular tract not only of leaves but also of stipules, bracts, calyx, corolla and even fruit. To the term *venules* was given preference, ribs, nerves and veins in zoology-sense not really occurring in the organisms of the empire of plants; the expression *veinlet* has long been used already in human and zoologic anatomy, whereas the word *venule* occurs as early as in the writings of Rheede, Cassearius and Commelin, the carinular *venule* of sepals and petals there very properly being called the intermediate. To this might be taken objection, because the so called midrib, which as such term would imply, could only be compared either to the sternum or spine of high-organized animal beings, is usually of such strength and solidity, that it could not be termed by a word implying tenderness and formed etymologically as a diminutive. But in the Australian Medical Journal of last year it has already been pointed out, that the *venæ-cavæ*, *portæ*, *azygos* &c. stand for calibre and firmness

in the same relation to the finer ramifications of the venous system of man and animals, as the strongest portion of the venular system of plants to its subtile anastomosis, the absolute structural identity of the whole venular plexus being at once apparent, when a leaf is skeletonized. Moreover we can by applying an adjective modify our expression, thus giving to what was called midrib, (a term contradictory in itself) the designation primary or longitudinal or carinular venule, or even merely keel, and can designate the other leaf-ribs readily as secondary or costular venules, while veins of leaves &c. could be called tertiary or ultimate or reticular or by any other adjective demanded in any special case.

Perhaps a happier expression can be devised than that of venules; but it will not be easy to find a term, which is universally applicable, when we consider, how within the genus *Acacia* even from the longitudinal parallel venulation almost of a monocotyledonous plant all transits occur to the reticular anastomosis in the phyllodes of respective species. If the words rhachis or rhacheole were not already otherwise employed, they might have been chosen for what is called the mid-rib of leaves; if to be considered costal at all, a diminutive from sternum would seem still more out of place than one from rhachis for such a homogenous and basi-fixed structure with ramifications often so numerous and so subtile. But the carinular venule, if ever so large, is never osseous, seldom fragile, often elastic and even flaccid, while the great veins of animal structures show also rigidity and some supportive strength. The remarks thus here offered should not merely apply to English organography, but ought to hold good internationally.

Although in innumerable cases the original interpretation of the fibro-vascular tract of the vegetative organs will remain permanently connected with specific and generic appellations, yet this should not militate against sounder organographic principles, even if our former etymology and nomenclature have ever so long been sanctioned by tradition. But it needs even in science some time, before we can get reconciled to alterations in customary fashions, however much warranted; and as regards the naming of plants, ruled and fixed by rights of priority, it might not be saying too much, that only for about one-third of the described species and genera the names are well selected, for another third passably and for the rest almost or quite inaptly.

The next expression, to which exception has been taken in the elaboration of my new work, is that of ovary; because we never employ the term ovum for the first stage of the seed of any plant. The inconsonance of the combination of ovary with ovule has long been perceived. In the phytographic literature of Italy the term *gemmularium* came into use with a view of bringing it into due and congruous relation to the word *gemmula*, that

expression having been substituted half a century ago by Endlicher, Schleiden and followers of theirs for ovulum; but they thus assigned to the word *gemma* a meaning quite different to that adopted by Richard and Bischoff, for what Linnæus, Gaertner and most authors up to our time comprehended under the name *plumula*. Much in accordance with my own views at the time, Endlicher used the word *germen* for ovarium; but considering the question in all its aspects, nothing seems to be logically clearer and more briefly expressive than the term *ovulary*, and this I have ventured now to introduce. An ovum of an insect might indeed become deposited not only in an ovulary but even in an ovule of a plant.

In entering on a further course of alterations in our botanic "glossaries," I have adopted for uniformity's sake several diminutives, to separate phytographic from zoographic expressions. Such etymology, as we all know, does not necessarily imply, that an organ should be of reduced size; for in our branch of science diminutive terms often simply indicate distinct portions of a compound organ; thus the leaflets of the leaf of a horse-chestnut-tree remain as well folioles as the minute leaflets of our Silver-Wattle, though comparatively of an enormous size; just as botanically speaking the fruitlets of many plants, for instance of the anonaceous order, or also of an *Albizzia* or even *Entada*, or (what is nearer home to us) of a *Marsdenia* may be of very conspicuous or even gigantic measurement, yet they all continue to be fruitlets, in contrast to true integral fruits, not even excluding such of the latter, as may be of almost invisible minuteness; structurally no differences can be drawn in these respects, a remark which applies likewise to the other new diminutives, which will be referred to presently. For the introduction of the word fruitlet (as well as that of stalklet, headlet, hairlet and bristlet) into the phytographic and indeed into the English language the writer of these lines is responsible; but Asa Gray, whose death we have now so much to deplore, formed already the word "nutlets" in translation of *nuculae*, (although by no means always of minute size) a linguistic innovation, approved of and practically adopted by Sir Joseph Hooker. In extending the general term fruitlets to all kinds of apocarpic fruits, whether nutlets or carpels (or rather carpids) or follicles or achenes or whatever else they may be called, the purposes of a plain elementary book are fully served; whereas strictly scientific distinctive appellations of all sorts of fruitlets can be reserved to professional publications according to the various views of authors. For the same reason the separate significations of integral fruits, such as capsule, drupe, berry, nut, *caryopsis*, utricle, pod and again achenes (the two last mentioned terms still frequently applied

to fruits of totally different structures) have not been thought requisite for the new publication, although occasionally an adjective has in these instances been added, to render the simple expressions, thus far used by the writer, more explicit when specially desirable. The next difficulty, which presented itself in bringing out in a popular form the "Dichotomous Key to the System of Victorian Plants," consisted in choosing such expressions for vestiture as could at once be understood, even by disciples of elementary schools, and which nevertheless should be scientifically accurate also. Here it should be stated then, that the terms for degree and quality of indument are as yet of notable indefiniteness, even in some of the best "Floras" of the world, partly on account of the brevity of expression, partly because from want of that uniformity for fixing the value of botanic terms, which Bischoff's great work previously strove to bring about long before the middle of this century. But in an endeavour of severing zoographic and phytographic expressions, we must at once recognize, that the vestiture of plants and animals is chemically very different, as may be ascertained in a moment by heating any such over a spirit-lamp on a platinum-plate; and further that the animal and the vegetable indument are not quite alike either in structure or development. Thus I felt induced to substitute as comprehensive the botanic word hairlet against the general zoologic term hair, to which latter all capillaceous coating of animals can be reduced, though for instance the hair of many insects may be even infinitely smaller and also much more delicate than the hairlets of a vast number of various plants. Admittedly in such a course shortness of expression becomes to some extent sacrificed, in as much as one or more explanatory adjectives are required for recording the characteristics of the various kinds of hairlets, which constitute any sort of clothing on plants. What however is lost in brevity, is gained by greater explicitness; and I have ventured to carry this new mode of dealing descriptively with vestiture so far, as to discontinue the words silky, downy, webby, plumous, ciliate, bearded, all pertaining to zoology, using instead only wordings fairly referable to vegetable organisms, such as fringy, cottony &c., or changing the absolute to the comparative term in substituting "beset with silk-like hairlets" for silky, or beard-like-tufted for bearded, or ciliate for ciliate, or lanuginous for woolly, already Plinius having distinguished in this very sense lanuginosus from lanosus! In further elucidation of this subject it might still be mentioned, that the following English diminutives have now universally been acknowledged as correct for descriptive botanic works: Branchlets, Leaflets, Lobules, Petiolules, Stipulelets or Stipelles, Pedicelles, Bractlets or Bracteoles, Umbellets or Umbellules, Involucelles, Spikelets, Rhacheoles, Silicules and

Nutlets ; to which from here have now been added : Hairlets, Bristlets, Headlets, Suturales and Fruitlets. It is also worthy of remark, that Lamarck has already objected to the term hermaphrodite as applied to plants, in that leaf-sheaths are only clasping leafstalks whether of Glumaceæ, Umbelliferae or any other kind of plants ; that spathes are amply developed bracts or altered floral leaves, that a spadix represents only some peculiar form of a spike, that glumes are simply bracts and paleæ are also, whether of Compositæ or Gramineæ ; that Vexillum or Standard, as well as Wings and Carina or Keel of papilionaceous flowers are as much petals, as any other ; therefore all these terms have, as cumbersome and superfluous for an elementary work, been discarded in the "Key." So early a writer as Fabius Columna has already adopted the word Capitulum for "flower-head" or headlet ; in French it is also Capitule, in German Koepfchen, in Italian Capolino, all diminutives. It must seem odd, particularly so to any tyro, when we speak of a starchy or horny Albumen, so contrary to all his preconceived notions. Certainly the verbal alteration proposed is but a trifling one, nor did the expression Alburnum arise from a classic scholar of high standing,—it originated with Publius Vegetius—but as Scheller, Luenemann and some other Lexicographers refer to the word, it can be rendered available for our new purpose. Very different is it with the term placentarium, for it emanated from so high an authority as that of Mirbel. It might be contended that such words as ribs, mouths and head do not exclusively belong to the domain of zoology, and that through the systematic names of plants they have become permanently identified with botanic science as a whole ; with regret the latter part of the proposition must be conceded ; but it might also as well be argued, that it would be preferable to call the mouth and head of rivers their entrance and source, though the extension of the term ribs to some of the framework of ships and boats must be admitted. Although the expression "Wings" exists also in architectural and military and even musical language, and although we may speak figuratively of the teeth of machinery and implements, these are not reasons against discarding any ambiguous or illogical terms from our bio-systematology. Possibly it might in the opinion of some systematists be preferable to construct altogether new words instead of such as are similar ; but of measures of this kind botanic science has been too prone already, particularly in recent times. While tentatively these changes in organography are introduced into our Australian Phytography, no one even here is prevented from adhering to—the certainly somewhat antiquated—so-called glossology in our particular branch of knowledge ; nor can an abolition of terms, clearly not the best, impair the utilisation of a mere "primer-publication." At all events, science cannot stand

still, although we should be conservative, so far as compatible with progressive discoveries.

The term *sepals* is restricted in the new work to calycine divisions free from beyond the base, so as to correspond thus far to petals; this necessitates the adoption of calyx-lobes for Orchideæ, Amaryllideæ and some other plants, to which hitherto *sepals* (or in other words perianth-segments) have been attributed, but whose calyx except in its ternary lobation quite repeats that of Campanulaceæ and numerous other plants among the Dicotyledonæ with perigynous (or epigynous) insertion of the corolla; the rationality of these limitations must be clear to every beholder. The designation *labellum* is reluctantly kept up for the lowest petal of all Orchideæ and most Candolleaceæ, not because it is necessary but because it is so innate in the respective literature, and does not imply anything organographically incorrect, although the changed third petal or the altered fifth corolla-lobe is hardly ever of a truly labial form, but contrarily a disparous organ, any counterpart being wanting. The word *scape* will always continue vague; it is not really needed, as it applies either to a stem or a flower-stalk.

The ambiguity of our organographic language in some respects will be further recognized in the employment of the term *disk*, as well for any internal lining of a calyx as for the aggregation of flowers on the receptacle of Compositæ; so also the word *columna* comprises widely different structures, not only the gynostemium and the staminal tube but often also the fruit-axis and the spermatophore; again *indusium* applies to two totally different organs, the stigma-cover of Goodeniaceæ and the sorus-cover of ferns; whereas for the inner bracts of Glumaceæ and any ultimate floral bracts of Compositæ alike the term *paleæ* is used, though both are not altogether identical; under *achenes* are frequently comprised not merely the fruitlets of apocarpic fruits, but likewise the simple fruits of Compositæ; the word *ligule* served hitherto as well for the terminal membrane of leafstalks of grasses as for the unilateral flat corolla-expansions of Compositæ and some allied orders; whereas the floral envelope of Monocotyledonæ, whether calycine or petaline, passes generally still as perianth or perigone, and so the calyx of apetalous Dicotyledonæ. Some reference to this subject occurs in the eighth volume of the "*Fragmenta Phytographiæ Australiæ*" (1874).

In the proposed new organography the term *floret* among diminutives hitherto in use would not really be requisite, not even for the most rudimentary flowers of Glumaceæ, and the word would, under the altered term now proposed, be particularly inapplicable to the well developed individual flowers of Compositæ. Thus another unnecessary word could be abolished, notwithstanding

the advocacy of diminutives in these pages, the aim of a popular book like the "Key" being also, to narrow down the "terminology" to such a minimum, as would still be consistent with exactitude. It would be a good plan, if phytographers as a whole could agree to the adoption of particular universally cultivated and rather unvariable garden-plants as typical, not only for degree and quality of vestiture, but also as standard-examples for form of leaves, colour of flowers, and other organographic definitions, concerning which Botanists and Horticulturists are by no means yet agreed, as proved by the vague application of even many a popular word for indument.

To sum up, then, I have placed side by side zoographic and phytographic terms, which are in many instances collateral, taking exceptional cases not into consideration.

Albumen ...	...	Albument (Albumentum).
Apophysis...	...	Terminal enlargement of fruit-stalk (of Mosses only.)
Beaked ...	...	Upwards much attenuated.
Bristle (Seta) ...	...	Bristlet (Setula).
Capillary ...	...	Capillulary.
Caruncle ...	...	Strophiole.
Chalazium ...	...	Chalaza.
Chin (Mentum) ...	...	Chin-like Protrusion.
Cilia ...	...	Cilioles.
Claw ...	...	Stalk-like Attenuation (of petals only).
Columnna ...	...	Columella.
Condyle ...	...	Protrusion into the cavity of some fruits.
Costal ...	...	Costular.
Digitate ...	...	Semi-radiatingly lobed.
Dorsal ...	...	Posterior.
Downy ...	...	Cottony.
Eared (Auritus) ...	...	Auricular.
Epidermis ...	...	Cuticle.
Facial ...	...	Anterior.
Faux ...	...	Orifice (of corolla only).
Favous ...	...	Favulous or favular.
Filule ...	...	Filament.
Fleshy ...	...	Carnulent.
Follicle ...	...	Anteriorly dehiscent fruit or fruitlet.
Fornices ...	...	Concave appendages (at corolla-orifice only).
Fovea (Fossa) ...	...	Foveole.
Genu ...	...	Geniculum.
Gland ...	...	Glandule.
Hair ...	...	Hairlet.
Head (Caput) ...	...	Headlet (Capitule, Capitulum).

Hermaphrodite ...	...	Bisexual Flower.
Horn ...	...	Horn-like Attenuation.
Leathery (Coriaceous) ...	...	Firmly or thickly or rigidly flat.
Limb ...	...	Calycine or Corollar Expansion.
Lingula ...	...	Ligule (ligula).
Lips (Labia) ...	...	Sets of Corolla-lobes.
Medulla (Marrow) ...	...	Pith.
Membrane ...	...	Membranule.
Mouth (Os) ...	...	Orifice.
Neck ...	...	Infra-terminal Constriction.
Nerve ..	...	Venule.
Node ...	...	Nodule.
Ovary ...	...	Ovulatory.
Ovum ...	...	Ovulum.
Palate ...	...	Convex Protrusion of lower side of Corolla-orifice.
Pedate ...	...	Anteriorly lobed.
Pedicle ...	...	Peduncle.
Penna ...	...	Pinna.
Placenta ...	...	Placentary (Placentarium).
Plumosus ...	...	Plume-like.
Raphe ...	...	Rapheole.
Rib... ...	...	Venule.
Rugous (Wrinkled) ...	...	Rugulous or Rugular.
Ruminat ...	...	Testa intruding or Albumen broken.
Scaly ...	...	Scale-like (where not bracts).
Septum ...	...	Dissepiment.
Silky ...	...	Silk-like invested.
Spine (vertebral) ...	...	Rhachis.
Squama (Scale) ...	...	Squamula (Scalet).
Suture ...	...	Suturule.
Tail ...	...	Basal Attenuation.
Teeth ...	...	Denticles.
Testa ...	...	Testula (of seeds).
Throat ...	...	Orifice (corollar only).
Tongue ...	...	Ligule (corollar only).
Toothed ...	...	Denticulated or Indented.
Tubercular ...	...	Verrucular.
Umbilical Cord ...	...	Funnicle.
Umbilicus... ...	...	Hilum.
Valve ...	...	Valvule.
Vein ...	...	Venule.
Velum ...	...	Velulum.
Ventral ...	...	Anterior.
Verrucous (Warty) ...	...	Verruculous or Verrucular.

Villous	...	...	...	Beset with long soft hairlets.
Vitellus (Yolk)	...	...	...	Separately integumented plumule only, or also the whole embryo within a separate loose integument.
Webby	...	...	...	Web-like.
Wing	...	...	...	Membranous Expansion.
Woolly	...	...	...	Lanuginous.

Preliminary references to these organographic alterations occur in a review of a portion of the "Key" by the learned editor of the "Victorian Naturalist," vol. iv., p. 179-180. (February, 1888.)

With the elder Reichenbach and some others I always held the opinion, that in a "systema naturæ" the identical name should not be applied to a botanic as well as to a zoologic genus; therefore preference was here given among Australian Orchids to the generic appellation *Sturmia*, instead of *Liparis*. Whoever may support this proposition will be obliged to adopt, for instance, also Reichenbach's *Learosa* for Endlicher's *Doryphora*, the last name being pre-occupied by Illiger for a coleopterous genus as far back as 1807. Where however changes in this respect are required, and not already made, it would be easy enough to substitute a slight alteration to the last syllable or otherwise to modify the generic word, without interfering with the author's right; and on this principle Zoographers and Phytographers might readily agree. As an instance might be cited the simian genus *Aotus* of Humboldt, established six years later than the leguminous genus of Smith, and subsequently changed into *Anotus*. How far up to 1845 zoologic and botanic names already clashed, can be seen on reference to Agassiz's ample "Nomenclator Zoologicus." Some Zoologists and Phytologists (particularly cryptogamic Phytologists) have unfortunately introduced, as very bewildering, the quoting of authors for species in genera which were not even established in the life-time of these naturalists; or, to be equally regretted, in dealing with generic alterations of species supersede the oldest correct binominal designation, by re-establishing the specific portion of a thus far justly discarded appellation; so *Wolffia Michellii* was purposely not called *arrhiza*, because all *Wolffias* are rootless, though this one had as *Lemna* received the name *L. arrhiza*. At the late evening of my life I may be permitted to remark, that I have never deemed such a treating of nomenclature as conducive to the real advancement of morpho-biology.

Here it might incidentally be asked, whether *Lemna polyrrhiza* and *L. oligorrhiza*, the fruits of which have here remained hitherto undiscovered and perhaps generally undeveloped, could through mineral manuring or any other nourishing processes be forced into ready flowering and perhaps even perfect fruiting states, so

that at last we might complete the diagnosis of these minute yet highly remarkable and not unimportant plantlets, although Dr. Samuel Johnson, of last century's literary celebrity, would very likely have relegated them to the division of useless plants as one of the two into which he would wish the vegetable kingdom apportioned !

As an instance of particular interest in Australia, how very much the nomenclature of plants may become complicated, the genus *Persoonia* may be adduced ; its earliest name is *Pentadactylon*—bestowed exactly a hundred years ago by Gaertner in his celebrated carpologic work, the pluri-cotyledonar structure of the embryo having already been then so cleverly found out—but subsequent researches proved, that this criterion applied to but few of the many species of that genus besides the primary one, irrespective of the fact, that an embryonic note is so little observable. Thus then Gaertner's generic appellation was perhaps with injustice discarded in favour of that of *Persoonia* ten years afterwards established by Sir James Smith, who however missed to identify it with Cavanille's genus *Linkia*, published and figured a year earlier. Undoubtedly *Persoonia* should be changed into *Linkia*, for although on chronologic reference the last mentioned name will be found applied in 1805 also to *Desfontainia*, simply because that genus is dedicated like *Fontanesia* to the same savant, yet there is no valid reason for abolishing *Delesseria*, with a view of keeping up a sole homage for Baron Benjamin de Lessert. Rules of priority should also not be carried out injudiciously and indiscriminately ; therefore it would be vain to re-establish the name *Lomandra* for the genus *Xerotes*, inasmuch as that designation was founded on a fallacious observation, the supposed marginal attenuation of the anthers referring only to the rudimentary stamens of the pistillate flowers. Names in Natural History whether of plants or animals, cannot be arbitrarily retained in some instances and changed in other similar cases ; the rule must be uniform, and then only can it be just ; but the etymology may be unalterably faulty, or the oldest appellation may rest on erroneous or misleading ideas or on wrong geographic record, while on the other hand the eldest name, as in the instances of *Bassia* and *Stylidium* may simply have been missed by a very pardonable oversight.

Let us follow up some Australian data in this respect. *Limnanthemum* stands in precisely the same relation to *Villarsia* as *Ipomœa aquatica* to its other congeners. If *Phebalium* is to be maintained, then *Boronia*, the next allied genus, needs to be divided into two genera. If *Euzolus* is to be abolished, then with *Portulaca* requires to be united *Claytonia*, a sub-genus of *Montia*. *Bassia* has become restored recently also by Schweinfurth,

Ascherson and Baillon, for Salsolaceæ. Like *Candollea* it was clearly and fully described; both were also illustrated at once by delineations and have indisputable rights of precedence. The priority of *Siebera* among Compositæ renders the homonymous genus among Umbelliferae superseded by *Didiscus*, a name universally familiar to Botanists and to Horticulturists also for the last 60 years. If the law of strict priority is not throughout to be observed, it will be quite incomprehensible, by what code all exceptions and deviations are to be admitted. In a case like that of *Guhnia* against *Cladium*, the first dual name in the former genus establishes the claim, though as a genus *Cladium* is of a much earlier date; their supposed distinctions in this case are rendered invalid by *Carex* within the same complex ordinal. Had the due restoration of such genera as *Wilckia*, *Hybanthus*, *Bramia* and *Laxmannia* been effected early in the century much synonymy would have been obviated, and less hesitation existed as to their recognition. In all this it must also be considered, that a phytographic system is to serve for centuries, and not merely to be in consonance with the traditions of a few generations.

A curious intrication exists as regards the name of one of the most common of our Senecios, which since 1803 passed as *S. australis*; it has recently been ascertained that its description by Willdenow is based on a variety of *Senecio lautus* from New Zealand, where our plant does not occur, so that the formerly current name has only the authority of A. Richard (Sert. Astrolab. t. 39) from 1833 for it; but the plant constitutes the *S. dryadeus* of Sieber, mentioned in 1826 by Sprengel (Syst. Veget. iii., 562). This case is merely given to show what accuracy is required for incontestable records in phytographic writings. *Todea* might well be reabsorbed in *Osmunda* (perhaps with exception of the section *Leptopteris*) in as much as *O. bipinnata* effects the transit. (See Hooker's Filices Exoticæ, t. 9.)

Now only remain some concluding remarks on ordinal affinities; for but few of these characteristics are by themselves absolute, not even that established already by Ray in reference to the number of Cotyledons; thus in Australia *Ceratophyllum*, *Nuytsia*, some *Persoonias* and *Callitris* have more than two cotyledons, while they are undeveloped in *Cuscuta*. The linear sequence of course is the only one available for practical descriptive purposes; so that, even in the most careful systematic arrangement, it becomes necessary to rely not too strictly on even main distinctive notes. To vindicate therefore some of the changes ventured on in the new publication, let us remember that numerous stamens occur in the Tropic-Australian genus *Distichostemon* among Sapindaceæ, and in two species of the Asiatic genus *Megacarpæa* among

Cruciferae; further that one Tasmanian species of *Eriostemon* has normally tetramerous flowers, that one Indian congener of *Eugenia* shows always scattered leaves, and that one New Zealand species of *Drosera* has quite perigynous stamens.

In transferring Viniferae to the vicinity of Rhamnaceae, as devised by Baillon, and more particularly to the proximity of Araliaceae, as simultaneously and independently recognized by Planchon and myself, we have to consider the enlarging fruit as placed superiorly merely through the small calyx remaining stationary in its development, an analogous case being presented by Exocarpos, thus far anomalous in the order of Santalaceae. To the altered position which Elatineae, Plumbagineae, Thymeleae, and Plantagineae have received, reference is made in my former writings.

Further alterations may hereafter yet be effected in the positions of some of the orders and particularly also genera. Certainly Ceratophyllum will have to be placed with ordinal rank between Cabombeae and the Batrachium-section of Ranunculaceae, as indicated long ago by Asa Gray and quite recently carried out by Engler, but on an interpretation of its floral organs, different to that previously given to it. So also may *Najas* perhaps need a transfer to Hydrocharideae, its achlamydeous pistillate flowers rendering the perigynism an impossibility, just as in the perhaps halorageous Callitriche. Loranthaceae and Proteaceae are left closely together; their near affinity is further demonstrated in quite an unexpected manner by the pluricotyledonar embryo of some of the *Persoonias* and of *Nuytsia* above alluded to, the latter having three to four cotyledons, or according to Drummond, several. (Hook., Journ. ii., 34, F.v.M., Fragm. vi., 252). That mere resemblance may however be deceptive, is shown by the genus *Jacksonia*, the species of which on hurried inspection might easily be taken for proteaceous plants. The flowers of Santalaceae so far as their floral envelope is concerned, might be compared to those of such Rubiaceae, which have a lobe-less calyx. In assigning to Proteaceae petals, as has been done in the more recent writings of mine, we need not take our clue from comparisons with Loranthaceae alone, because the genera *Acacia*, *Asterolasia* and *Rhododendron*, have in some or many species their calyx also undeveloped; *Anemone* and *Caltha*,—to speak only of genera represented in Australia—are rather esepalous than apetalous. *Diplolæna* is also devoid of a calyx, and many other instances might be referred to pertaining to this subject of systematology. Laurineae are often far removed from Magnoliaceae and Anonaceae, but the aromatic properties, largely developed in these orders, point already to near cognateness.

The union of the epigynous with the perigynous main groups, adhered to in later writings of mine, was effected already as early

as 1823 by Achille Richard ("Histoire des medicamens, des poisons et des alimens tirés du règne végétal," in two volumes). Otherwise that work follows Jussieu's system, only the portion comprising the Apetalæ rendering that natural system, as a whole imperfect. But what has been cursorily explained in these pages forms but few of the thousandfold proofs, how nature in its freedom sportively overleaps the boundaries, by which systematists vainly endeavour to narrow the endless and marvellous forms of its organisms for strict literary arrangement or demarcation.

INDIGENOUS AUSTRALIAN FORAGE PLANTS, (Non-GRASSES) INCLUDING PLANTS INJURIOUS TO STOCK.

By J. H. MAIDEN, F.L.S., &c., Curator of the Technological Museum, Sydney.

[Read before the Royal Society of N.S.W., June 6, 1888.]

OWING to the severity of the droughts, (and in some districts, the competition of rabbits and other vermin) cattle and sheep in Australia have at times to endeavour to preserve existence by devouring any vegetable matter whatsoever. The plants therefore eaten by stock embrace a very large number of species, but I have confined myself in the following pages to references to the plants usually eaten by them, either because they are abundant, or readily withstand the drought, or because stock are very partial to browsing upon them. The poisonous plants of course come under different category. If I were to record the names of all *suspected* poisonous plants, the list would be a very large one. The observations of bushmen as to the poisonous nature of certain plants, are not always to be relied on,* and the enquiry even to a scientific man, is attended with much difficulty. In "Plants injurious to Stock," (Bailey and Gordon), Govt. Printer, Brisbane, will be found references to a number of suspected plants, but in regard to many, the verdict of "not proven" must be entered.

* The allegation is from time to time made in the newspapers, that sometimes through ignorance, and sometimes as a matter of expediency, squatters report that their sheep or cattle have fallen victims to poison-weeds, when in reality they have perished from disease. Whatever the extent of this misrepresentation may be, it is an undoubted fact that during the last few years, many instances of alleged poisoning by weeds having been enquired into on the spot by a competent veterinarian, have been proved to have been caused by disease.

See also "Remarks on some indigenous shrubs of South Australia suitable for culture as fodder." (S. Dixon). *Proc. R. S. of S.A.*, Vol. viii. See also a paper by the Rev. Dr. Woolls, "On the Forage Plants indigenous in New South Wales." (*Proc. Linn. Soc., N.S.W.*, vii., 310.)

Notes on the plants eaten (whether from inclination or necessity) by stock, with good or bad results, the distribution of them, together with any other particulars bearing upon their use as fodder-plants, are much required, as the systematic recording of such information is even yet (at least as far as Australia is concerned) in its infancy. It is highly desirable to collect seeds of each useful (or likely to be useful) fodder-plant, for experimental cultivation, either with the view to its improvement under such treatment, or with the view to acclimatise it in some other country in which it is not indigenous or already introduced. A careful system of exchange of this kind cannot but result in benefit to the countries concerned.

1. *ABRUS PRECATORIUS*, *Linn.*, B. Fl., ii., 270. Syn.: *A. pauciflorus*, Desv.; *A. squamulosus*, E. Mey. N.O. Leguminosæ. The pretty little red seeds with black spots are called "Crabs' Eyes," and "Jequirity Seeds." Found in Queensland and Northern Australia.

This plant is not sufficiently abundant in Australia to affect stock to an appreciable extent, but it is interesting to observe that the Cattle Plague Commission of India (1877) in their Report, mentioned that a large number of the criminal cases of cattle-poisoning are effected through the agency of the seeds of this plant. More extended enquiry showed that this practice was common throughout the greater part of India. (Dymock.)

2. *ACACIA ANEURA*, and other species, *F. v. M.*, B. Fl., ii., 402. N.O. Leguminosæ. "Mulga," forming the chief ingredients of the scrub of that name. Found in all the Colonies except Tasmania.

The leaves are eaten by stock. In the Technological Museum are samples of wool from sheep fed exclusively on this shrub on a station in Western Queensland. The wool is not of the first quality, as might be expected, but it is very good. The following are some of the particulars of the wool:—

Wool of ewe hoggets (under 10 months' growth), average length of staple $2\frac{3}{4}$ inches.

Wool of wether hoggets (12 months' growth), average length of staple 4 inches.

Wool of 4-tooth ewes (18 months' growth), length of staple $6\frac{1}{4}$ inches.

3. *ACACIA DORATOXYLON*, *A. Cunn.*, B. Fl., ii., 403. N.O. Leguminosæ. "Spear-wood," a "Brigalow," "Currawang" or "Caariwan," "Hickory." Found in all the Australian Colonies except Tasmania and Western Australia.

The leaves are eaten by stock.

4. *ACACIA PENDULA*, *A. Cunn.*, B. Fl., ii., 383. Syn.: *A. leucophylla*, Lindl. N. O. Leguminosæ. "Weeping or true Myall." Called "Boree" and "Balaar" by the aborigines of the Western Districts. Found in New South Wales and Queensland.

Stock are very fond of the leaves of this tree, especially in seasons of drought, and for this reason, and because they eat down the seedlings, it has almost become exterminated in parts of the Colony.

5. *ACACIA SALICINA*, *Lindl.*, B. Fl., vii., 367. Syn.: *A. ligulata*, *A. Cunn.* N. O. Leguminosæ. "Native Willow," and "Broughton Willow," near the Broughton River (Northern S.A.). Called "Cooba" or "Koobah" by the aborigines of Western New South Wales, and "Motherumba" by those on the Castlereagh River, New South Wales. Found in all the Colonies except Tasmania.

The leaves are eaten by stock. This is another tree which is rapidly becoming scarce owing to the partiality of stock to it.

6. *ALBIZZIA BASALTICA*, *Benth.*, B. Fl., ii., 422. Syn.: *Acacia basaltica*, *F. v. M.* N. O. Leguminosæ. "Dead finish." Found in Queensland.

Cattle like the foliage of this tree.

7. *ANGOPHORA INTERMEDIA*, *DC.*, B. Fl., iii., 184. Syn.: *Metrosideros floribunda*, *Smith.* N.O. Myrtaceæ. "Narrow-leaved Apple-tree." Found in Victoria, New South Wales, and Queensland.

8. *ANGOPHORA SUBVELUTINA*, *F. v. M.*, B. Fl., iii., 184. Syn.: *A. velutina*, *F. v. M.* N. O. Myrtaceæ. "Broad-leaved Apple-tree." Found in New South Wales and Queensland.

The Rev. Dr. Woolls states that these "Apple-trees" are sometimes cut down to keep cattle alive in dry seasons, as the leaves are relished by them.

9. *ALBIZZIA LOPHANTHA*, *Benth.*, B. Fl., ii., 421. Syn.: *Acacia lophantha*, *Willd.*; *Mimosa distachya*, *Vent.*; *M. elegans*, *Andr.* N.O. Leguminosæ. Found in Western Australia.

Cattle browse on the leaves of this tree. It is, however, of rapid growth.

10. *APIUM LEPTOPHYLLUM*, *F. v. M.*, B. Fl., iii., 372. Syn.: *Helosciadium leptophyllum*, DC. N.O. Umbelliferae. "Wild Parsley." Found in Victoria, New South Wales, and Queensland.

Occasionally eaten by stock. It is worthy of note that this plant (in common with others of the genus) is sometimes arid and injurious when grown in damp soils. It is doubtless capable of much improvement by careful cultivation. This plant is not endemic in Australia.

11. *ATALAYA HEMIGLAUCA*, *F. v. M.*, B. Fl. i., 463. Syn.: *Thouinia hemiglauca*, *F. v. M.* N. O. Sapindaceae. "Cattle-bush," "White-wood." Found in South Australia, New South Wales and Queensland.

The leaves of this tree are eaten by stock, the tree being frequently felled for their use during seasons of drought.

12. *ATRIPLEX BILLARDIERI*, *Hook. f.*, B. Fl., v., 180. *A. crystallinum* in Muell. Cens., p. 30. Syn.: *A. crystallina*, *Hook. f.*; *Obione Billiardieri*, *Moq.*; *Theleophyton Billardieri*, *Moq.* N.O. Chenopodiaceae. A "Salt-bush." Several species of this genus are indigenous in England, where they go by the name of "Orache." Found in all the Colonies except Queensland and Western Australia.

This herb vegetates solely in salty coast-sands, which, like *Cakile*, it helps to bind, on the brink of the ocean and exposed to its spray. (Mueller.)

13. *ATRIPLEX CAMPANULATA*, *Benth.*, B. Fl., v., 177. N.O. Chenopodiaceae. "Small Salt-bush." Found in South Australia, New South Wales and Queensland.

Salt-bushes are so appreciated by stock that in many parts of the Colonies they are far less plentiful than they used to be. Unless flock-masters can see their way clear to keep their sheep &c., in certain paddocks, while the vegetation in others is endeavouring to recuperate, this kind of vegetation will continue to diminish, to the detriment of the pastoral industry. Greedy cropping of Salt-bush without any efforts at conservation is assuredly "killing the goose with the golden eggs." An analysis of this Salt-bush by Mr. W. A. Dixon, will be found *Proc. Royal Society N.S.W.*, 1880, p. 133.

14. *ATRIPLEX HALIMOIDES*, *Lindley*, B. Fl., v., 178. Syn.: *A. Lindleyi*, *Moq.*; *A. inflata*, *F. v. M.* N.O. Chenopodiaceae. A "Salt-bush." Found in all the Colonies except Tasmania.

Found over the greater part of the saline desert-interior of Australia, reaching the south and west coasts. A dwarf bush, with its frequent companion *A. holocarpum*, F.v.M., among the very best for salt-bush pasture. (Mueller.)

15. *ATRIPLEX NUMMULARIA*, Lindley, B. Fl., v., 170. N.O. Chenopodiaceæ. "Old-man Salt-bush," or "Cabbage Salt-bush." Found in all the Colonies except Western Australia and Tasmania.

One of the tallest and most fattening pastoral salt-bushes ; also highly recommended for cultivation as natural plants by close occupation of the sheep and cattle runs, have largely disappeared, and this useful bush is not found in many parts of Australia. Sheep and cattle depastured on salt-bush country are said to remain free of fluke and get cured of Diastoma disease and of other allied ailments. (Mueller.)

An analysis by Mr. W. A. Dixon will be found *Proc. Royal Society, N.S.W.*, 1880, p. 133.

16. *ATRIPLEX SEMIBACCATA*, R. Brown, B. Fl., v., 175. N.O. Chenopodiaceæ. A "Salt-bush." Found in all the Colonies except Tasmania.

A perennial herb much liked by sheep.

17. *ATRIPLEX SPONGIOSA*, F.v.M., B. Fl., v., 179. Syn.: *A. semibaccata*. Mog., non R. Br. N.O. Chenopodiaceæ. Found through a great part of Central Australia, extending to the West Coast.

A useful salt-bush for culture.

18. *ATRIPLEX VESICARIA*, Heward, B. Fl., v., 172. N.O. Chenopodiaceæ. A "Salt-bush." Found in the interior of South-Eastern Australia, also in Central Australia and Western Australia.

Perhaps the most fattening and most relished of all the dwarf salt-bushes of Australia, holding out in the utmost extremes of drought, and scorched even by the hottest winds. Its vast abundance over extensive salt-bush plains of the Australian interior, to the exclusion of almost every other bush except *A. halimoides*, indicates the facility with which this species disseminates itself. (Mueller.)

19. *AVICENNIA OFFICINALIS*, Linn., B. Fl., v., 69. Syn.: *A. tomentosa*, Jacq. N.O. Verbenaceæ. A "Mangrove" or "White Mangrove." The "Tchoonchee" of some Queensland

aboriginals, and the "Tagon-tagon" of those of Rockhampton (Queensland), and "Egaie" of those of Cleveland Bay. Found in all the Colonies (round the coast) except Tasmania.

The leaves of this tree are eaten by cattle, and are considered very nutritious.

20. *BARRINGTONIA ACUTANGULA*, Gaertn., B. Fl., iii., 288. Syn.: *Stravadium rubrum*, DC. N.O. Myrtaceæ. Found in Northern Australia.

Brandis, (*Forest Flora of India*) states that the bark of this tree, mixed with pulse and chaff, is given as cattle-fodder in India.

21. *BOERHAAVIA DIFFUSA*, Linn., B. Fl., v., 277. Syn.: *B. pubescens*, R. Br.; *B. procumbens*, Roxb. N.O. Nyctagineæ. Called "Goitcho" by the natives of the Cloncurry River, Northern Queensland. Found in all the Colonies except Tasmania.

The Rev. Dr. Woolls points this out as a useful forage plant, which, having a long tap-root, can withstand a considerable amount of drought, whilst it affords pasture early in the season ere the grasses are developed. This plant is not endemic in Australia. It is a troublesome weed in some warm countries.

22. *BULBINE BULBOSA*, Haw., B. Fl., vii., 34. Syn.: *B. australis* Spreng.; *B. suavis*, Lindl.; *B. Fraseri*, Kunth; *B. Hookeri*, Kunth; *Anthericum bulbosum*, R. Br.; *A. semibarbatum*, Hook. N.O. Liliaceæ. "Native Onion," "Native Leek." Found in all the Colonies except Western Australia.

Mr. W. N. Hutchison, Sheep Inspector, Warrego, Queensland, reports of this plant:—"Its effects on cattle, sheep and horses are almost the same—continually lying down, rolling, terribly scoured, mucous discharge from the nose of a green and yellowish colour. Cattle survive the longest; sheep take some three days, and horses will linger for a week." In *Plants injurious to Stock*, (Bailey and Gordon) two cases of poisoning are also instanced.

23. *BURSARIA SPINOSA*, Cav., B. Fl. i., 115. Syn.: *Itea spinosa*, Andr. N.O. Pittosporææ. "Native Box." Found in all the Colonies.

It is greedily eaten by sheep, but its thorny character preserves it from extinction upon sheep-runs. It is variable in bulk, usually a small shrub, in congenial localities it develops into a small tree.

24. *CASSIA EREMOPHILA* (nemophila), A. Cunn., B. Fl., ii., 287. Syn.: *C. canaliculata*, R. Br.; *C. heteroloba*, Lindl. N.O. Leguminosæ. Found in all the Colonies except Tasmania.

Mr. S. Dixon states that both the pods and leaves of this plant are eaten by stock.

25. *CASTANOSPERMUM AUSTRALE*, A. Cunn., B. Fl. ii., 275. N.O. Leguminosæ. "Moreton Bay Chestnut," "Bean-tree." Called "Bogum" and "Irtalie," by the aborigines. Found in Northern New South Wales and Queensland.

Stockowners are destroying this tree owing to the belief that cattle are poisoned through eating the seeds. They are however quite harmless when cooked, and form, in fact, part of the diet of the aborigines.

The Government Analyst of New South Wales has failed to find an alkaloid or poisonous principle in the seeds, and suggests that they may be injurious on account of their indigestibility. (*Report of Dept. of Mines, N.S.W.*, 1886, p. 46). It is however, to be borne in mind that the Leguminosæ are emphatically a poisonous Natural Order, although they yield some of the most valuable foods of man and beast.

26. *CASUARINA STRICTA*, Ait., B. Fl., vi., 195. *C. quadrivalvis* in Muell. Cens., p. 22. Syn.: *C. quadrivalvis*, Labill.; *C. macrocarpa*, A. Cunn.; *C. cristata*, Miq.; *C. Gunnii*, Hook. f. N.O. Casuarinæ. "Coast She-oak," "Swamp Oak," "River Oak." "Worgnal" of the aborigines. Found in all the Colonies except Queensland and Western Australia.

Mr. S. Dixon states that in Port Lincoln (S.A.), the fallen catkins (male inflorescence), form the chief sustenance in winter on much of the overstocked country.

The foliage is eagerly browsed upon by stock, and in cases of drought these trees are pollarded for the cattle. Old bullock-drivers say that cattle prefer the foliage of the female plant (i.e. those plants with the fruit-cones) to that of the male. (J. E. Brown.) *Casuarina* foliage has a pleasant acidulous taste, but it contains a very large proportion of ligneous matter.

Mr S. Dixon (*op. cit.*) states that this tree is too sour to be very useful to ewes rearing lambs, but if sheep had only enough of it, the "braek" or tenderness of fibre, would often be prevented in our finer wool districts, and much money saved by the increased value a sound staple always commands.

27. *CASUARINA SUBEROSA*, Otto. et Dietr., B. Fl., vi., 197. Syn.: *C. leptoclada*, Miq.; *C. mæsta*, F.v.M. N.O. Casuarinæ. "Erect She-oak," "Forest Oak," "Swamp Oak," "River Black-oak," "Shingle Oak," "Beef-wood." "Dahl-wah" of the aborigines. Found in all the Colonies except South and Western Australia.

A very valuable fodder-tree ; largely used and much valued in the interior districts as food for stock during periods of drought. The same remarks apply more or less to all species of *Casuarina*.

28. *CEDRELA TOONA*, *Roxb.*, B. Fl., i., 387. *C. australis* in Muell. Cens., p. 9. Syn.: *C. australis*, F.v.M. N.O. Meliaceæ. Ordinary "Cedar." Called "Polai" by the aborigines of northern New South Wales, "Mumin" or "Mugurpul" by those about Brisbane, and "Woota" by those about Wide Bay, Queensland. Found in New South Wales and Queensland.

The leaves are used to feed cattle in India. (Gamble.) It should be observed however, that Baron Mueller differs from Bentham in considering the Australian "Cedar" specifically distinct from the "Toon" of India. In any case, the trees are so closely related that any property possessed by the one is shared by the other.

29. *CLAYTONIA POLYANDRA*, *F.v.M.*, B. Fl., i., 172. Syn.: *Talinum polyandrum*, Hook. N.O. Portulacææ. "Coonda" of the aborigines about Shark's Bay, Western Australia. Found in the interior of New South Wales, South, Western, and Northern Australia.

Sheep can largely feed on this succulent shrub for a considerable time without drinking water. (Mueller and Forrest, "*Plants indigenous about Shark's Bay, W.A.*," 1883). The same observation is doubtless true of the other *Claytonias*, and also of the closely related *Portulaca oleracea*, the common Purslane.

30. *CHIONANTHUS RAMIFLORA*, *Roxb.*, B. Fl., iv., 301. *Mayepea ramiflora*, F.v.M. in Muell. Cens., p. 92. Syn.: *C. effusiflora* F.v.M.; *Linociera effusiflora*, F.v.M.; *L. ramiflora*, DC.; *Mayepea ramiflora*, F.v.M. N.O. Jasmineæ. Found in Queensland.

The fruit of this plant is the food of the Jagged-tailed Bowerbird (*Prionodura Newtoniana*). (Bailey.) This observation is interesting, and is the more valuable in that the vegetable foods of our indigenous fauna have very rarely been botanically determined. This plant is not endemic in Australia.

31. *CLAYTONIA* (*Calandrinia*) *BALONNENSIS* OR *BALONENSIS*, *Lindl.*, B. Fl., i., 172. N.O. Portulacææ. "Munyerroo of natives of South Australia. "Periculia" of natives of Central Australia. (*Fragm.*, x., 71.) Found in South Australia, New South Wales and Queensland.

Mr. S. Dixon states that a large mob of cattle, destined to stock a Northern Territory run, travelled some 200 miles without a

drink, which would have been altogether impossible in the absence of this succulent plant.

32. *CONOSPERMUM STÆCHADIS*, *Endl.*, B. Fl., v., 375. Syn.: *C. sclerophyllum*, *Lindl.* N.O. Proteacæ. Found in Western Australia and New South Wales.
33. *CONOSPERMUM TRIPLINERVIVM*, *R. Brown*, B. Fl., v., 374. Syn.: *C. laniflorum*, *Endl.*, *C. undulatum*, *Lindl.* N.O. Proteacæ. Found in Western Australia.

Baron Mueller suggests that these plants be tried on the worst desert country, as all kinds of pasture animals browse with avidity on the long, tender and downy flower-stalks and spikes, without touching the foliage, thus not destroying the plant by close cropping.

34. *CUCUMIS TRIGONUS*, *Roxb.*, B. Fl., iii., 317. Syn.: *C. pubescens* *Hook.*; *C. jucundus*, *F.v.M.*; *C. picrocarpus*, *F.v.M.* N.O. Cucurbitacæ. "Boomarrah" of the aboriginals of the Cloncurry River, North Queensland. Found in New South Wales, Queensland, Northern and Western Australia.

Stock are said to be very fond of this plant in the Western districts of Queensland. (Bailey). Sir Thomas Mitchell speaks of this plant covering a great area of ground, in one of his journeys in western New South Wales.

35. *DAUCUS BRACHIATUS*, *Sieb.*, B. Fl., iii., 376. Syn.: *Scandix glochidiata*, *Labill.* N.O. Umbelliferæ. "Native Carrot." Found in all the Colonies.

Stock are very fond of this plant when young. Sheep thrive wonderfully on it where it is plentiful. It is a small annual herbaceous plant growing plentifully on sandhills and rich soil, the seeds, locally termed "carrot burrs," are very injurious to wool, the hooked spines, with which the seeds are armed, attaching themselves to the fleece, rendering portions of it quite stiff and rigid. The common carrot belongs of course to this genus, and the fact that it is descended from an apparently worthless, weedy plant, indicates that the present species is capable of much improvement by cultivation. This plant is not endemic in Australia.

36. *DAVIESIA* spp. N. O. Leguminosæ. "Hop-bush." Found chiefly in Western Australia, but also in New South Wales and other Colonies.

Some of these shrubs are called "hop-bushes" on account of the pleasant bitter principle which pervades them. Horses and cattle are fond of browsing on them.

37. *DODONÆA LOBULATA*, *F.v.M.*, B. Fl., i., 479. N.O. Sapindaceæ.
 "Hop-bush." Found in Southern and Western Australia,
 New South Wales and Victoria.

One of the best fodder shrubs in the Lachlan district of New South Wales. The seed pods in particular contain a very pleasant bitter. There is no reason to suppose that this particular species is preferred by stock to any other of the genus, only I have not seen it recorded that sheep, cattle, &c., have actually been observed to browse upon any other, with the exception of *D. viscosa*.

38. *EREMOPHILA LONGIFOLIA*, *F.v.M.*, B. Fl., v., 23. Syn. :
Stenochilus longifolius, R. Br. ; *S. salicinus*, Benth. ; *S. pubiflorus*, Benth. N. O. Myoporineæ. "Emu-bush,"
 "Dogwood." "Berrigan" of the natives. Found in all the
 Colonies except Tasmania.

The leaves are greedily eaten by cattle and sheep. Observations in regard to the effect on stock browsing upon plants belonging to the *Myoporineæ* are much needed, as statements hitherto made in respect to them are not always reconcilable. Mr. S. Dixon states that this tree is one of the first to be barked by rabbits.

39. *EREMOPHILA MACULATA*, *F.v.M.*, B. Fl., v., 29. Syn. :
Stenochilus maculatus, Ker. ; *S. racemosus*, Endl. ; *S. curvipes*
 Benth. N. O. Myoporineæ. Called "Native Fuchsia" in
 parts of Queensland. Found in all the Colonies except
 Tasmania.

This is considered poisonous by some, and by others a good fodder-bush.

It does not appear to be dangerous to stock accustomed to eat it, but to others, travelling stock particularly, Mr. Hutchison of Warrego, (Q.) considers it to be deadly. The effects of this plant are always worst after rain. It appears to be most dangerous when in fruit. (Bailey & Gordon.)

40. *EREMOPHILA MITCHELLI*, *Benth.*, B. Fl., v., 21. N. O.
 Myoporineæ. "Rosewood" or "Sandalwood." Found in
 New South Wales and Queensland.

The leaves are eaten by stock. The seeds of several species are eaten by Emus.

41. *EUCALYPTUS CORYNOCALYX*, *F.v.M.*, B. Fl., iii., 218. Syn. :
E. cladocalyx, *F.v.M.* N. O. Myrtaceæ. "Sugar Gum."
 Found in South Australia.

The sweetish foliage of this tree is browsed upon by cattle and sheep ; in this respect this Eucalypt may be classed with one other — *E. Gunnii*. (J. F. Brown.)

42. *EUCALYPTUS GUNNII*, *Hooker f.*, B. Fl., iii., 246. Syn.: *E. ligustrina*, Miq.; *E. acervula*, Hook. f. N. O. Myrtaceæ. "White Swamp Gum" or "Cider Gum." It possesses some other vernacular names. Found in Tasmania, the extreme south-eastern portion of South Australia, thence to Gippsland, and into New South Wales as far as Berrima.

This tree also bears the name of the "Sugar Gum," because of the sweetness of the leaves, which consequently are browsed upon by stock. It is a common tree in Tasmania, where it is called "Cider Gum," as an excellent cider is made from the sap taken from it in the spring-time.

43. *EUCALYPTUS PAUCIFLORA*, *Sieb.*, B. Fl., iii., 201. Syn.: *E. coriacea*, A. Cunn., (the species name in B. Fl.); *E. plebophylla* F.v.M.; *E. submultiplinervis*, Miq.; *E. piperita* var. *pauciflora* DC., and *E. procera*, Dehn. (perhaps). N. O. Myrtaceæ. "White Gum," "Drooping Gum." It is sometimes called "Mountain Ash." It possesses other vernacular names. Found in Tasmania, Victoria and New South Wales.

The leaves of this tree are very thick, and in dry seasons are eaten by cattle. (Woolls.)

Opossums have a predilection for the young foliage of this tree, so that they often kill trees of this species.

44. *EUPHORBIA ALSINÆFLORA*, *Baill.*, B. Fl., vi., 49. N. O. Euphorbiaceæ. Found in Northern Australia.

This plant is said to be a dangerous poison-herb to sheep. The natural order is emphatically a poisonous one.

45. *EUPHORBIA DRUMMONDII*, *Boiss.*, B. Fl., vi., 49. N. O. Euphorbiaceæ. Called "Caustic creeper" in Queensland. Called "Milk plant" and "Pox plant" about Bourke. Found throughout the Colonies.

This weed is unquestionably poisonous to sheep, and has recently (Oct. 1887) been reported as having been fatal to a flock near Bourke, N.S.W.

It has been observed that when eaten by sheep in the early morning before the heat of the sun has dried it up, it is almost certain to be fatal. It is seldom eaten except by travelling sheep, and when grass is scarce. Its effect on sheep is curious. The head swells to an enormous extent, being so heavy that the animal cannot support it, and therefore drags it along the ground; the ears get much swollen and suppurate. (Bailey & Gordon.)

Following is Mr. S. Dixon's remarks on this plant:—"A friend of mine fed some old ewes on the undoubtedly poisonous *E.*

Drummondii, but could not kill them, although he had often lost an odd sheep or two from poison, and no other known poisonous plant exists on his property."

46. *EUPHORBIA EREMOPHILA*, *A. Cunn.*, *B. Fl.*, v., 52. Syn.: *E. deserticola*, F.v.M. N.O. Euphorbiaceæ. Found in all the Colonies except Tasmania.

This plant should be perhaps placed in the "Suspected" list. In the western interior some people say it is highly poisonous, others, as usual, say that they have seen sheep eat it with not the least injurious result. Mr. Bauerlen gathered a quantity of this plant for the Technological Museum and appended the following note: "The plants I send I gathered in a horse-paddock. There was plenty of evidence on the plants that horses or cattle browse on it, but no injurious result is recorded at the station."

47. *FICUS GLOMERATA*, *Willd.*, *B. Fl.*, vi., 178. Syn.: *F. vesca*, F.v.M.; *Covellia glomerata*, *Miq.* N.O. Urticææ. "Clustered fig." Found in Queensland and Northern Australia.

The leaves are used in India for cattle and Elephant fodder. (Gamble, *Manual of Indian Timbers*.)

48. *FLAGELLARIA INDICA*, *Linn.*, *B. Fl.*, vii., 10. N.O. Liliaceæ. "Lawyer Vine." Found in New South Wales, Queensland and Northern Australia.

Leichhardt, *Overland Journey to Port Essington*, p. 424, speaks of his bullocks feeding heartily upon this plant, particularly as the country was most wretched, and the grass scanty and hard.

This plant is not endemic in Australia.

49. *FLINDERSIA MACULOSA*, F.v.M., *B. Fl.*, i., 389. *Flindersia Strzeleckiana*, F.v.M.; *Elæodendron maculosum*, *Lindl.*; *Strzeleckya dissosperma*, F.v.M. N.O. Meliaceæ. "Spotted tree," "Leopard tree." Found in northern New South Wales and Queensland.

During periods of drought sheep become exceedingly fond of this tree, which they greedily devour, as well as the twigs up to the size of a goose-quill, and hence the tree is in danger of extermination as it has not the recuperative power of some trees.

50. *GASTROLOBIUM* spp., especially *G. obovatum*, *Benth.*, *G. trilobum*, *Benth.*, *G. spinosum*, *Benth.* (syn. *G. Preissii*, *Meissn.*) *G. oxylobioides*, *Benth.*, *G. calycinum*, *Benth.*, *G. callistachys*, *Meissn.*, (syn. *G. lineare*, *Meissn.*) *G. bilobum*, *R. Br.*; *B. Fl.* ii., 101-7. N. O. Leguminosæ. Commonly known as "Poison bushes." At the Blackwood River, according to

Oldfield *G. calycinum* is known as the "York Road Poison bush." Found in Western Australia.

These plants are dangerous to stock, and are hence called "Poison-bushes." Large numbers of cattle are lost annually in Western Australia through eating them.

"The finest and strongest animals are the first victims: a difficulty of breathing is perceptible for a few minutes, when they stagger, drop down, and all is over with them. After the death of the animal the stomach assumes a brown colour; and is tenderer than it ought to be; but it appears to me that the poison enters the circulation, and altogether stops the action of the lungs and heart.* The raw flesh poisons cats, and the blood, which is darker than usual, dogs; but the roasted or boiled flesh is eaten by the natives and some of the settlers without their appearing to suffer any inconvenience." (Drummond, in Hooker's *Journal of Botany*.)

"The blossoms are also frequently eaten by animals, and are, I think, the most poisonous part, for the greatest number of sheep are lost from the poisonous effect of this plant at the period of its inflorescence. When the seeds fall on the ground, the wild pigeons greedily feed and fatten on them; if the crops of these pigeons, containing the seeds, be eaten by dogs, they die, yet the pigeons themselves when dressed, are good food, and at that season are eaten in large numbers by the settlers. Horses, so far as is known are not effected by it, at least this is the prevailing opinion, although it is disputed by some of the settlers." (T. R. C. Walter, in *Pharm. Journ.*, vi., 311.)

With sheep who have eaten the herb the best treatment has been found to be to fold them, or shut them up in a close yard, so closely packed that they can hardly move, and to keep them thus without food for thirty-six hours. See an interesting account in *Pharm. Journ.*, vi., 311.

In the *Flora Australiensis*, a statement is quoted that *G. bilobum* is the worst of the "Poison shrubs." Certainly some of them render extensive tracts of country unoccupiable.

51. *GASTROLOBIMUM GRANDIFLORUM*, F.v.M., B. Fl., ii., 103. N.O. Leguminosæ. "Wall-flower or Desert Poison-bush. Found in Queensland and Northern Australia.

With one exception, this is the only *Gastrolobium* out of Western Australia, and it is the only Queensland one. Baron Mueller identified this plant as having poisoned large numbers of cattle and sheep on the Cape River, and at the sources of the

* See also an interesting account of some physiological experiments to ascertain the nature of the poison. *Pharm. Journ.*, vi., 312.

Burdekin and Flinders Rivers in 1863-4. He recommends frequent burning off on the stony ridges it frequents with the view to its suppression or eradication.

52. *GEIJERA PARVIFLORA*, Lindl., B. Fl., i., 364. Syn.: *G. pendula*, Lindl. N.O. Rutaceæ. "Wilga," "Sheep-bush," "Dogwood" and "Willow." Found in all the Colonies except Tasmania.

Mr. S. Dixon states that sheep only are particularly fond of this bush, and it seems quite unaffected by droughts.

53. *GERANIUM DISSECTUM*, Linn., B. Fl., i., 296. *G. carolinianum* in Muell. Cens. p. 13. Syn.: *G. pilosum*, Forst.; *G. parviflorum*, Willd.; *G. philonothum*, DC.; *G. potentilloides*, L'Hér.; *G. australe*, Nees; *G. carolinianum*, Linn. N.O. Geraniaceæ. "Crowfoot," "Terrat" of the aborigines of the Coranderrk Station Victoria. Found throughout the Colonies.

This plant is known and highly prized as a very superior pasture herb. It is very plentiful during the spring time of good seasons on the sandhills. The seeds—which ripen about the end of September—are very injurious to sheep and wool, and, when this plant is plentiful, often cause the death of numbers of sheep, and if the shearing is late injure the wool to a very great extent. The seeds, which have exceedingly sharp, hard, barbed points, readily attach themselves to wool or the skins of sheep, whilst the spiral shaft with the long crank attached gives the whole the action of an auger worked by the movements of the animal or the action of the winds. If the point of one of these seeds is struck lightly into the sand on a windy day it will soon bury itself up to the base: this is how the seeds are planted by nature. Injurious as this plant is, it has its redeeming points, for it is one of our most nutritious fodder plants, all kinds of stock being exceedingly fond of it, and when cut in a green state and before the seeds mature it makes excellent hay. This plant is not endemic in Australia.

54. *GOMPHOLOBIUM UNCINATUM*, A. Cunn., B. Fl., ii., 46. N.O. Leguminosæ. Found in New South Wales.

This small shrub is noteworthy as being very hurtful to sheep that may eat of it. (*Treasury of Botany*.)

South Australia is quoted (*op. cit.*) as its habitat, but this is a mistake.

55. *GOSSYPIUM STURTII*, F.v.M., B. Fl., i., 222. Syn.: *Sturtia gossypioides*, R. Br. N.O. Malvaceæ. Found in South Australia and New South Wales.

This plant affords stock a good summer food. (Dixon.)

56. *HETERODENDRON OLEAFOLIUM*, Desf., B. Fl. i., 469. N.O. Sapindaceæ. "Emu Bush," "Jiggo" and "Behroging" are aboriginal names. Found in all the Colonies except Tasmania.

The seeds which are dry, are eaten by emus. Mr. S. Dixon states that both sheep and cattle feed greedily upon it.

57. *HIBISCUS HETEROPHYLLUS*, Vent., B. Fl., i., 212. Syn.: *H. grandiflorus*, Salisb. N.O. Malvaceæ. "Green Kurrajong." "Dtharang-gange" is an aboriginal name. Found in New South Wales and Queensland.

The leaves, branches and bark of this tree are greedily eaten by cattle in winter. They are mucilaginous, in common with other plants of this natural order.

58. *JACKSONIA SCOPARIA* var. *MACROCARPA*, R. Br., B. Fl., ii., 60. *J. cupulifera*, in Muell. Cens., p. 34. Syn.: *J. cupulifera*, Meissn. N. O. Leguminosæ. "Dogwood." Found in Western Australia.

Cattle and horses relish the foliage of this small tree amazingly. (Mueller.)

59. *KOCHIA APHYLLA*, R. Br., B. Fl., v., 188. Considered by Baron Mueller to be a variety of *K. villosa*, (Muell. Cens. p. 30). N.O. Chenopodiaceæ. A Salt-bush. Found in all the Colonies except Tasmania.

"All kinds of stock are often largely dependent on it during protracted droughts, and when neither grass nor hay are obtainable I have known the whole bush chopped up and mixed with a little corn, when it proved an excellent fodder for horses. One drawback it has, its stems being very fibrous, and the older portions indigestibly so, it is the principal cause of those bezoars or felted knobs in the manipulus of the sheep, which in very protracted droughts kill them by hundreds. When, however, the rains come, and soft herbage is abundant, these bezoars either partially dissolve or become covered with a shiny black coating, so that they resemble a papier-maché ball."

60. *KOCHIA PYRAMIDATA*, Benth., B. Fl., v., 186. N.O. Chenopodiaceæ. "Blue-bush." Found in South Australia, Victoria, and New South Wales.

An analysis of this Salt-bush by Mr. W. A. Dixon is to be found in *Proc. Royal Society, N.S.W.*, 1880, p. 133.

61. *KOCHIA VILLOSA*, Lindl., B. Fl., v., 186. Syn.: *K. tomentosa*, F.v.M.; *K. pubescens*, Moq.; *Maireana tomentosa*, Moq. N.O. Chenopodiaceæ. Found in all the Colonies except Tasmania.

A valuable salt-bush which withstands a very high temperature.

But Mr. S. Dixon (op. cit.) states that this species is "hateful" to stock. See *K. aphylla*.

62. *LOTUS AUSTRALIS*, Andr., B. Fl., ii., 188. Syn.: *L. lævigatus*, Benth.; *L. albidus*, Lodd. N.O. Leguminosæ. Found in all the Colonies.

63. *LOTUS CORNICULATUS*, Linn. N.O. Leguminosæ. Found in all the Colonies except Western Australia and Queensland.

These plants are often reputed poisonous in Australia, which is doubtless a mistake, as they make excellent fodder, and are considered valuable ingredients in meadows and pastures. (Bailey.)

Doubtless this idea has arisen owing to the poisonous nature of some leguminous bushes similar in leaf and habit. Baron Mueller however states (*Trans. R. S., Victoria*, Vol. vi., 1861-4) that this plant causes sheep to perish in some cases, in half-an-hour.

The most contrary evidence as to the effect of these plants on stock is to hand from Western New South Wales.

"I am inclined to believe that many leguminous plants reputed to be poisonous are not really so, but that an excess of either foliage or seeds eaten by a hungry animal throws off such an abundance of gases, that "hoove," which is nothing more than an excessive distension of the stomach, pressing against the diaphragm, preventing the lungs from working, and the animal is really strangled to death. To this cause I attribute all the deaths (and they are very numerous) caused by *Lotus australis* var. *Behrii*, really an excellent fodder plant, akin to the Lucernes, but when seeding, and especially after rain, if hungry sheep are allowed to feed greedily upon it, they die by hundreds, while sheep in confinement and fed solely upon it do not die, but actually thrive as was shown some years since in Adelaide." (S. Dixon, op. cit.)

64. *MALVASTRUM SPICATUM*, A. Gray, B. Fl., i., 187. Syn.: *Malva spicata*, Linn.; *M. ovata*, Cav.; *M. timorensis*, DC.; *M. brachystachya*, F.v.M. N.O. Malvaceæ. Found in South Australia, New South Wales and Queensland.

Some squatters have considered this a valuable sheep-herb. (Bailey.) This plant is not endemic in Australia.

65. *MARSILEA QUADRIFOLIA*, Linn., B. Fl., vii., 683. Syn.: *M. Brownii*, A. Braun; *M. angustifolia*, R. Br.; *M. hirsuta*, R. Br.; *M. Drummondii*, A. Braun. N.O. Marsiliaceæ. "Clover Fern." Found in all the Colonies except Tasmania.

This plant is much relished by stock. It grows plentifully in swamps and shallow pools of water. It is however better known as yielding an unsatisfactory human-food in its spore-cases.

66. *MYOPORUM DESERTI*, A. Cunn., B. Fl., v., 5. Syn.: *M. dulee*, Benth.; *M. strictum*, A. Cunn.; *M. patens*, A. Cunn.; *M. rugulosum*, F.v.M. N.O. Myoporineæ. "Ellangowan Poison Bush" of Queensland. "Dogwood Poison-bush" of New South Wales. Found in all the Colonies except Tasmania.

This appears to be a well authenticated poison-bush, but apparently only when in fruit. It is reported from Ellangowan, Darling Downs, Queensland, and out of a flock of 7,000 sheep passing Yandilla, (Q.) 500 succumbed to eating this plant. (Bailey and Gordon.)

67. *MYOPORUM PLATYCARPUM*, R. Br., B. Fl., v., 7. Syn.: *Disoon platycarpus*, F. v. M. N. O. Myoporineæ. "Dogwood," "Sandalwood." Found in all the Colonies except Victoria and Queensland.

The leaves are eaten by stock, but not as far as I can learn, with any evil effects. It is often felled for sheep in time of drought.

68. *NICOTIANA SUAVEOLENS*, Lehm., B. Fl., iv., 469. Syn.: *N. undulata*, Vent.; *N. Australasica*, R. Br.; *N. rotundifolia*, Lindl.; *N. fastigiata*, Nees. N.O. Solanææ. "Native Tobacco." Found in all the Colonies except Tasmania.

This plant grows luxuriantly on the sand-hills in the Riverina district (New South Wales) in good seasons. It used in the early days of the Colony, and in the interior districts up to quite recent years, to be manufactured into tobacco. It is readily eaten by stock.

69. *PIMELEA HÆMATOSTACHYA*, F. v. M., B. Fl., vi., 22. N.O. Thymelææ. Found in Queensland.

This very handsome plant might with advantage be introduced into garden culture, but it is one of the worst of poisonous herbs, and often causes the loss of hundreds of sheep, yet their lives could perhaps be saved by slitting their ears soon after they had eaten the herb. (Bailey.)

70. *PITTOSPORUM PHILLYRÆOIDES*, DC., B. Fl., i., 112. Syn.: *P. angustifolium*, Lodd. N.O. Pittosporææ. Called variously "Butter-bush," "Willow tree," "Native Willow," and "Poison-berry tree." Found in all the Colonies except Tasmania.

In times of scarcity this tree is of great value, as it withstands drought, and sheep and cattle browse upon its foliage. Stock are so partial to it in the interior districts that it is in danger of extermination in parts, and it is a tree which should be conserved.

71. *PLANTAGO VARIA*, *R. Br.*, *B. Fl.*, v., 139 (where see synonymy).
Syn.: *P. debilis*, Nees. N.O. Plantaginæ. Found in all the Colonies.

This plant is relished by stock. Speaking of an allied species (*P. lanceolata*), an English writer observes:—"Its mucilaginous leaves are relished by sheep, and, to a certain extent, by horses and cattle, but it seldom answers as a crop, unless on very poor land where little else will grow. It was generally sown with clover, and this mixed crop is occasionally seen now on barren soils; but there can be little doubt that the plantain is inferior in produce, and probably in nutritive qualities, to many plants that would grow equally well on the same land. Mingled with grasses in permanent pasture, it may be beneficial in small quantity, but tends, like all broad-leaved plants, to destroy the more delicate herbage around it."

72. *POMADERIS RACEMOSA*, *Hook.*, *B. Fl.*, i., 421. N.O. Rhamnæ.
Found in all the Colonies except Western Australia and Queensland.

The leaves when chewed or soaked are found to be slightly mucilaginous; this explains the fondness that stock have for this plant. It always seems fresh and green, and stands stocking well. (S. Dixon.)

73. *PSORALEA TENAX*, *Lindl.*, *B. Fl.*, ii., 193. N.O. Leguminosæ.
Found in New South Wales and Queensland.

Considered a good fodder by some. (Bailey.)

74. *PTERIGERON ADSCANDENS*, *Benth.*, *B. Fl.*, iii., 533. N.O. Compositæ. Found in Queensland and Northern Australia.

Specimens of this plant have been frequently sent to Brisbane as a poison herb. (Bailey.)

75. *RHOGODIA* spp., *B. Fl.*, v., 151, et seq. N.O. Chenopodiace.
"Salt-bushes."

The plants are palatable to sheep and cattle on account of the salt which they contain, nearly two ounces having been obtained from two pounds of leaves; and they are all more or less useful, but the two following are perhaps best known.

76. RHAGODIA BILLARDIERI, *R. Brown*, B. Fl., v., 152. Syn.: *R. baccata*, Moq.; *R. Candolleana*, Moq.; *Chenopodium baccutum*, Labill. N.O. Chenopodiaceæ. Found in all the Colonies.

This is an important bush for binding moving sand on sea-shores. (Mueller.) It is eaten by stock.

77. RHAGODIA PARABOLICA, *R. Br.*, B. Fl., v., 153. Syn.: *R. reclinata*, A. Cunn. N.O. Chenopodiaceæ. "Salt-bush." Found in all the Colonies except Tasmania.

This plant is relished by stock.

78. SARCOSTEMMA AUSTRALE, *R. Br.*, B. Fl., iv., 328. N.O. Asclepiadææ. Called "Caustic Plant" or "Caustic Vine" in Queensland; "Gaoloowurrah" by the aborigines at Port Darwin. Found in all the Colonies except Victoria and Tasmania.

In the Warrego District, Queensland, a great number of fat cattle have perished from eating this plant. The death of sheep from eating it is also well authenticated. (Bailey & Gordon.)

Yet Mr. J. Dixon stated he had not known stock to touch this plant till the summer of 1880-1, when the cattle on the eastern plains of South Australia lived upon it, without water, for some months of continued drought. (*Proc. R.S., S.A.*, iv., 136.)

79. SCLEROLENA BICORNIS, *Lindl.*, B. Fl., v., 195. *Bassia bicornis* in Muell. Cens., p. 30. This must not be confounded with the Sapotaceous genus *Bassia* of Linn., which are usually large trees. (*Genera Plantarum*, Benth. & Hook., ii., 658.) Syn.: *Chenolea bicornis*, (*Vide Proc. R.S.*, 1880); *Kentropsis lanata*, Moq.; *Anisacantha bicornis*, F. v. M.; *Bassia bicornis*, F. v. M. N.O. Chenopodiaceæ. "Cotton-bush." Found in all the Colonies except Tasmania and Western Australia.

[N.B.—In Mr. Dixon's paper the name is given as *Chenolea bicornis*. There is no such species. It is probably intended for *Sclerolæna bicornis*.]

An analysis of this salt-bush by Mr. W. A. Dixon is in the *Proc. Royal Society, N.S.W.*, 1880, p. 133.

80. SESBANIA ÆGYPTIACA, *Pers.*, B. Fl., ii., 212. Syn. *Æschynomene sesban*, Linn. N.O. Leguminosæ. "Ngeen-jerry" of the aborigines of the Cloncurry River (North Queensland). Found in Northern Australia.

The leaves and branches are cut for cattle-fodder in India. (Gamble.)

81. *SIDA RHOMBIFOLIA*, Linn., B. Fl., i., 196. N.O. Malvaceæ.
 "Common Sida weed," "Queensland hemp." Called "Paddy Lucerne" in the Clarence and Richmond River Districts of New South Wales. It is often called "Native Lucerne" in other parts of the Colony. Found in New South Wales to Northern Australia.

It may not be generally known that the ripe carpels of this weed often cause the death of fowls that feed on them, by the sharp terminal arms of the carpels irritating the inside and causing inflammation. (F. M. Bailey.)

The leaves are mucilaginous, as are also the tops, and cattle are very fond of them. They are however unable to destroy the plants, by reason of the very strong fibre in the stems.

82. *SOLANUM EREMOPHILUM*, F. v. M., B. Fl., iv., 459. N.O. Solanæe. Found in the interior of New South Wales and South Australia.

Between Cobham and Mount Arrowsmith (New South Wales), an old drover stated that he has repeatedly seen sheep and cattle die after eating this pretty blue and purple plant.

83. *SOLANUM SIMILE*, F. v. M., B. Fl., iv., 448. Syn.: *S. laciniatum*, var., R. Br.; *S. fasciculatum*, F. v. M. N.O. Solanaceæ. Found in all the Colonies except Tasmania and Queensland.

Sheep feed on this plant. (Annie F. Richards, in *Proc. R.S., S.A.*, iv., 136.)

84. *STERCULIA DIVERSIFOLIA*, G. Don., B. Fl., i., 229. *Brachychiton populneum* in Muell. Cens., p. 15. Syn.: *Brachychiton populneum*, R. Br.; *Pæcilodermis populnea*, Schott. N.O. Sterculiaceæ. "Kurrajong" or "Black Kurrajong." The "Bottle-tree" of Victoria. Found in Victoria, New South Wales, and Queensland.

Cattle and sheep are fond of the leaves and branches, and in some dry seasons have existed for long periods on scarcely anything else. In parts of the Riverina (New South Wales) the trees are cut down as required for this purpose. (*General Report, Sydney International Exhibition*, 1879.)

85. *SWAINSONIA* spp., B. Fl., ii., 216, et seq. N.O. Leguminosæ. Native Indigos.

These plants are reputed poisonous to stock. The active principle does not appear to have been isolated, as it only exists during certain stages of growth (prior to flowering) of the plant, and it seems to be decomposed on drying the plant. The real

nature of the poison will therefore probably remain undetermined until such time as a chemist can work at the plant on the spot, or take steps to receive a perfectly fresh supply of it.

86. SWAINSONIA GAGLEGIFOLIA, *R. Br.*, B. Fl., ii., 217. Syn.: *S. Osbornii*, Moore; *Vicia galegifolia*, Andr.; *Colutea galegifolia*, Sims. N.O. Leguminosæ. "Darling Pea." "Indigo Plant." Found in New South Wales and Queensland.

This is a dreaded plant from the great amount of loss it has inflicted on stock-owners. Its effect on sheep is well known; they separate from the flock, wander about listlessly, and are known to the shepherds as "pea eaters," or "indigo eaters." When once a sheep takes to eating this plant it seldom or never fattens, and may be said to be lost to its owner. The late Mr. Charles Thorn, of Queensland, placed a lamb which had become an "indigo eater" in a small paddock, where it refused to eat grass. It however ate the indigo plant greedily, and followed Mr. Thorn all over the paddock for some indigo he held in his hand. At Taroom (Q.) horses were hobbled for the night at a place where much of this plant was growing. On the following morning they were exceptionally difficult to catch, and it was observed how strange they appeared. Their eyes were staring out of their heads, and they were prancing against trees and stumps. The second day two out of nine died, and five others had to be left at the camp. When driven they would suddenly stop, turn round and round, and keep throwing up their heads as if they had been hit under the jaw; they would then fall, lie down for a while, rise, and repeat the agonizing performance. On one station in the course of a few weeks, eight head were shot, having injured themselves past all hope of recovery. (*Plants Injurious to Stock*, Bailey and Gordon.)

The Rev. Dr. Woolls, however, points out (*Proc. Linn. Soc., N.S.W.*, vii., 315) that from experiments made near Mudgee, New South Wales, it does not appear that this species is deleterious when eaten with other herbage.

87. SWAINSONIA GREYANA, *Lindl.*, B. Fl., ii., 216. Syn.: *S. grandiflora*, *R. Br.* N.O. Leguminosæ. "Poison bush." Found in South Australia, Victoria, New South Wales, and Queensland.

This plant is reported to cause madness, if not death itself, to horses. The poison seems to act on the brain, for animals affected by it obstinately refuse to cross even a small twig lying in their path, probably imagining it to be a great log. Sometimes the poor creatures attempt to climb trees, or commit other eccentricities. (Woolls.) It is regarded with great horror on

the Darling, especially in dry seasons when other herbage fails. Baron Mueller believes in the poisonous properties attributed to this particular species. (*Trans. R. V., Victoria*, Vol. vi., 1861-4.) It would appear to be very similar in its effects to the preceding species.

"I may add that this plant is popularly supposed to produce a sort of insanity, ending in some cases in death, in stock that feed upon it. I am of opinion that this is incorrect; I have never seen any stock actually feeding upon it, but I have seen horses eat freely, without any evil effect, of another species of the same genus (?) which grows plentifully on the black soil flats which are at times inundated by the waters of the Darling. The Hon. William Macleay, who has had large experience in a district where this plant grows, informed me a few days ago that he also was of opinion that it is not poisonous to stock." (H. R. Whittel, in *Proc. Linn. Soc., N.S.W.*, ix., 179.) As testimony in regard to the properties of *S. Greyana* this is a little vague, but I have given it verbatim.

88. *TEPHROSIA PURPUREA*, Pers., B. Fl., ii., 209. Syn.: *T. piscatoria*, Pers., and others. N O. Leguminosæ. Found in South Australia, New South Wales to Northern Australia.

These species possess properties deleterious to stock. The latter was reported from the Flinders River, Queensland, as a poison herb. (Bailey and Gordon.) *T. rosea*, F. v. M., is also poisonous.

89. *TRACHYMENE AUSTRALIS*, Benth., B. Fl., iii., 349. *Didiscus pilosus* in Muell. Cens., p. 62. Syn.: *Didiscus pilosus*, Benth.; *D. anisocarpus*, F. v. M.; *D. grandis*, F. v. M.; *Dimetopia anisocarpa*, Turcz.; *D. grandis*, Turcz. N.O. Umbelliferae. "Wild Parsnip." Found in all the Colonies.

Recently (December, 1887) the sudden death of numbers of cattle in the vicinity of Dandenong, Victoria, was attributed to their having eaten a plant known as the wild parsnip. Baron Mueller pronounced specimens forwarded to him by the Chief Inspector of Stock to belong to this species. Its action is so powerful that no remedial measures seem to be of any avail. The only way to destroy the plant is to pull it up by the roots and burn it.

90. *TREMA ASPERA*, Blume, B. Fl., vi., 158. (This, and other species of *Trema* recorded by Bentham, are all united by Baron Mueller under the typical *T. cannabina*, Lour. Vide

Muell. Cens., p. 21.) Syn. : *Celtis aspera*, Brong. ; *Sponia aspera*, Planch. N.O. Urticæ. "Peach-leaved poison bush," "Elm," "Rough fig," a "Kurrajong." Found in all the Colonies except South and Western Australia.

This shrub is firmly believed by some to be poisonous. It is likely very indigestible, as it produces an excellent strong fibre. (Bailey.)

91. *TRICHODESMA ZEYLANICUM*, *R. Br.*, B. Fl., iv., 404. *P. zeylanica* in Muell. Cens., p. 100. Syn. : *Pollichia zeylanica*, F. v. M. N.O. Boraginæ. Found in all the Colonies except Victoria and Tasmania.

Baron Mueller recommends this plant as a fodder herb, saying that the dromedaries of Giles' Exploring party (1873-4) were found to be particularly partial to it. It is not endemic in Australia.

92. *TRIGONELLA SUAVISSIMA*, *Lindley*, B. Fl., ii., 187. N.O. Leguminosæ. From its abundance in the neighbourhood of Menindie it is often called "Menindie Clover." It is the "Australian Shamrock" of Mitchell, and the "Calomba" of the natives of the Darling. Found in the Interior of Australia, from the Murray River and tributaries to the vicinity of Shark's Bay, Western Australia.

This perennial, fragrant, clover-like plant is a good pasture herb. Sir Thomas Mitchell (Three Expeditions) speaks of it in the highest manner as a forage plant on several occasions.

93. *VENTILAGO VIMINALIS*, *Hook.*, B. Fl., i., 411. N.O. Rhamnæ. "Supple Jack." "Thandorah" of the aborigines of the Cloncurry River (North Queensland). Found in South Australia, New South Wales, and Queensland.

The leaves are eaten by stock.

94. *ZIZYPHUS JUJUBA*, *Lam.*, B. Fl., i., 412. N.O. Rhamnæ. "Jujube tree." Found in Queensland.

The leaves are much valued for cattle-fodder in India. (Brandis.)

WEDNESDAY, 4th JULY, 1888.

Sir ALFRED ROBERTS, President, in the Chair.

Twenty-four members were present.

The minutes of the last meeting were read and confirmed.

The certificates of three new candidates were read for the third time, of two for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Johnson, Alexr. Mackey, M.D., Ch. M., K. Univ., *Irel.*,
Sydney.

Mullins, George Lane, B. A., M. B., Trin. Coll., *Dub.*,
F.R.M.S., Sydney.

Roth, Walter E., B.A., *Oxon.*, Sydney.

The Chairman announced that the Council had resolved to hold a *Conversazione* in the Great Hall of the University, on Wednesday, 5th September.

A discussion took place upon Mr. W. E. Abbott's paper on "Forest Destruction in New South Wales, and its Effect on the Flow of Water in Water-courses and on the Rainfall," read at the previous Monthly Meeting, in which the following gentlemen took part, viz.: Messrs. F. B. Gipps, H. C. Russell, J. F. Mann, Hon. G. H. Cox, M.L.C., J. B. Henson, W. M. Hamlet, Rev. S. Wilkinson, and the Author.

Mr. H. C. Russell, B.A., F.R.S., read a paper on "An Improvement in Anemometers." A discussion ensued, in which Profr. Threlfall, Messrs. J. S. Mitchell, the Hon. G. H. Cox, J. F. Mann, the Chairman, and the Author took part.

In the absence of the author, the Hon. Secretary read a paper by the Rev. J. E. Tenison-Woods, F.L.S., on "The Anatomy and Life-History of *Mollusca* peculiar to Australia," the paper was illustrated by coloured drawings and a series of microscopic slides.

The thanks of the Society were accorded to the various Authors for their valuable papers.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF JUNE, 1888.

(The Names of the Donors are in *Italics*.)

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- CAMBRIDGE (Mass.)**—Cambridge Entomological Club. *Psyche*, Vol. v., No. 145, May, 1888. *The Club.*
- CORDOBA**—Academia Nacional de Ciencias. Boletín, Tomo x., Entrega 1, June, 1887. *The Academy.*
- DRESDEN**—Generaldirection der Königl. Sammlungen für Kunst und Wissenschaft. Archiv für Litteraturgeschichte, Band xv., Heft 1-4, 1887. Bericht über die Verwaltung und Vermehrung der Königlichen Sammlungen für Kunst und Wissenschaft zu Dresden in den Jahren, 1884 und 1885. Der Witterungsverlauf zu Dresden, 1879-1885. *The Director-General.*
- EDINBURGH**—Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. iv., No. 5, May, 1888. *The Society.*
- FLORENCE**—Società Africana d'Italia, Sezione Fiorentina. Bullettino, Vol. iv., Fasc. 3 & 4, 5th May, 1888. *"*
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- LONDON**—Geological Society. Quarterly Journal, Vol. 44, Part 2, No. 174, May 1, 1888. *"*
- Linnean Society. Journal—Zoology, Vol. xxii., No. 139. *"*
- Meteorological Office. Hourly Readings, 1885, Part 2, April to June, *Official* No. 74. Report of the Meteorological Council to the Royal Society, for the year ending 31st March, 1887. Monthly Weather Report for January and February, 1887. Weekly Weather Report, Second Series, Vol. iv., Nos. 46-52, 1887. Appendix i., Quarterly Summary, Oct. to Dec., 1887, Values for the whole Year, Appendices ii., iii., & iv., Vol. v., Nos. 1 to 7. *The Meteorological Office.*
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- MULHOUSE—Société Industrielle. Bulletin, Jan.-Feb.-Mar., 1888. *The Society.*
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- PHILADELPHIA—Franklin Institute. Journal, Vol. cxxv., No. 749, May, 1888. *The Institute.*
 Zoological Society. Annual Report (16th) of the Board of Directors, 26th April, 1888. *The Society.*
- ROME—Ministero dei Lavori Pubblico. Giornale del Genio Civile, Anno xxvi., Fasc. 2, Feb., 1888. *The Minister of Public Instruction, Rome.*
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- SAINT ETIENNE—Société de l'Industrie Minérale. Comptes Rendus Mensuels, Mar., 1888. *The Society.*

- SYDNEY**—University. Calendar of the University of Sydney for the year 1888. *The University.*
- VIENNA**—K. K. Geologische Reichsanstalt. Verhandlungen, Nos. 17 & 18, 1887, Nos. 1 to 6, 1898. *The "Reichsanstalt."*
- WASHINGTON**—Bureau of Education. Circular of Information, No. 3, 1887. *The Bureau.*
- Chief of Engineers U.S. Army. Annual Report to the Secretary of War for the year 1887, Parts i., ii., iii., and iv. *The Chief of Engineers U.S. Army.*
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MISCELLANEOUS.

(Names of Donors are in *Italics*.)

- American Philosophical Society, Philadelphia.—Laws and Regulations as finally amended and adopted Dec. 18, 1885. List of Surviving Members, March 5, 1886. Proceedings at the Dinner commemorative of the Centennial Anniversary of the Incorporation of the Society, March 15, 1880. Register of Papers published in the Transactions and Proceedings. *Profr. Liversidge, M.A., F.R.S.*
- Catalogue of Exhibition at Tokio, 2 Vols. „ „
- Friedländer, R. & Sohn.—Bücher-Verzeichniss, Nos. 377 to 380 incl., 8° Berlin, 1888. *The Publishers.*
- Gibbs, J. Willard.—On Multiple Algebra, 8° Salem, Mass., 1886. *Profr. Liversidge, M.A., F.R.S.*
- Macadam, W. Ivion, F.I.C., F.C.S.—Manures, Natural and Artificial, 4° London, 1888. *The Author.*
- Microscopical Bulletin and Science News.* Vol. v., Nos. 1 & 2, 1888. *W. H. H. Linn.*
- Rousdon Observatory, Devon.—Meteorological Observations for the Year 1887, Vol. iv. *Cuthbert E. Peek, M.A., &c.*
- Shelford, W., M.I.C.E., and Shield, A. H., A.M.I.C.E.—On the Design of Girder Bridges. *The Authors.*

WEDNESDAY, AUGUST 1st, 1888.

SIR ALFRED ROBERTS, President, in the Chair.

Fifteen members were present.

The minutes of the last meeting were read and confirmed.

The certificates of two new candidates were read for the third time, of two for the second time, and of three for the first time.

The ballot for the election of the candidates whose certificates had been read for the third time, was postponed to the next General Meeting in consequence of a quorum not being present.

The following letter was read from Professor Rücker :—

Savile Club, 107 Piccadilly, W.,
November 21st, 1887.

Dear Professor Liversidge.

It is generally assumed that in the Northern Hemisphere rocks which affect the direction of the declination magnet attract the North Pole.

This would of course be the case with a mass of soft iron one extremity of which was deeply imbedded in the earth. The earth's magnetism would induce a south-seeking pole in the upper end which would attract the north-seeking pole of a magnet in its neighbourhood.

In the Magnetic Survey of the United Kingdom on which Dr. Thorpe and I have been engaged, we have in several instances observed this effect.

I am not however aware as to whether the truth of the supposition has ever been tested in the Southern Hemisphere. If not I think it would be worth attention.

I should therefore be very glad if you could obtain for me any information as to whether rocks in Australia which contain (1) magnetite (2) iron ore other than magnetite attract the south-seeking pole of a magnet in their neighbourhood.

I am, very truly yours,

ARTHUR W. RÜCKER.

Mr. D. M. Maitland stated that some years ago while in the Tumut district he found the southern end of the magnetic needle attracted by magnetic ore in the ground.

Professor Warren, M. Inst. C.E., then exhibited and described the Autographic Stress-strain Diagram-drawing apparatus, as used at the University of Sydney in recording the results of testing materials in tension, compression, and cross-breaking. The usefulness of the apparatus was explained at some length, and a quantity of interesting information was given. It was stated that the machine would pull from 1 lb. to 100,000 lbs. The Professor showed the manner in which the apparatus is used in recording the results of testing the transverse strength and elasticity of beams of iron and timber; the results of testing iron and timber columns; and the results of testing the tensile strength and elasticity of all materials. A cordial vote of thanks was accorded to the Professor for the interesting description he had given of the apparatus. Professor Warren, in reply, said he would have the machine in working order at the Sydney University on the 5th of September next, the date on which the Society's biennial conversazione will be held. This reunion will take place in the Great Hall of the University.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF JULY, 1888.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

ADELAIDE—Report on the Progress and Condition of the

Botanic Garden during the year 1887.

The Govt. Botanist.

- BERLIN**—Königlich Preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 40 to 54, 20 Oct. to 22 Dec. 1887 and Index. *The Academy.*
- BRISBANE**—Acclimatisation Society of Queensland. Report of the Council for the year 1887. *The Society.*
 Meteorological Bureau. Account of the Operations of the Weather Bureau and List of Stations, 2 July, 1888. *The Govt. Meteorologist.*
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- CALCUTTA**—Asiatic Society of Bengal. Descriptions of New Indian Lepidopterous Insects *Heterocera* by Frederic Moore, F.Z.S., &c., Part iii., 1888. "
- Geological Survey of India. Memoirs *Palæontologia Indica*, Ser. xiii., Vol. i., Part 7. *The Director.*
- CAMBRIDGE (Mass.)**—Cambridge Entomological Club. "Psyche," Vol. 5, No. 146, June 1888. *The Club.*
- EDINBURGH**—Royal Physical Society. Proceedings, Vol. ix., Part 2, Session 1886. *The Society.*
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- FLORENCE**—Società Italiana di Antropologia, Etnologia e Psicologia. Archivio, Vol. xvii., Fasc 3, 1887. *The Society.*
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- MANCHESTER**—Literary and Philosophical Society. Memoirs, Third Series Vol. x.; Proceedings, Vols. xxv. and xxvi., Session 1885-7. *The Society.*
- MELBOURNE**—Field Naturalists' Club of Victoria. *The Victorian Naturalist*, Vol. v., No. 3, July, 1888. *The Club.*
- MEXICO**—Sociedad Científica "Antonio Alzate." Memorias, Tomo i., Cuaderno Núm. 9, 10, 11, 1888. *The Society.*

- MULHOUSE—Société Industrielle de Mulhouse. Bulletin, Avril, 1888. *The Society.*
- NEWCASTLE-UPON-TYNE—Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne. Transactions, Vol. ix., Part 2, 1888. „
- North of England Institute of Mining and Mechanical Engineers. Transactions, Vol. xxxvii, Part 4, 1888. *The Institute.*
- NEW YORK—American Chemical Society. Journal, Vol. viii., No. 8, 1886; Vol. ix., No. 8, 1887. *The Society.*
- Science, Vol. xi., Nos. 278 to 281, June 1st to 22nd, 1888. *The Editors.*
- PALERMO—Reale Accademia di Scienze, Lettere e Belle Arti. Bulletino, Anno iii., Num. 6, 1886; Num. 1—6, 1887. Gennaro-Febbraio, 1888. *The Academy.*
- PHILADELPHIA—Franklin Institute. Journal, Vol. ccxv., No. 750, June, 1888. *The Institute.*
- PARIS—L'Observatoire de Paris. Rapport Annuel, pour l'année, 1887. *The Observatory.*
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- Société de Géographie. Compte Rendu, No. 6, 1888. „
- Société Géologique de France. Bulletin, 3e Série, Tome xvi., Nos. 2 and 3, 1888. „
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- TOKIO—Imperial University. Journal of the College of Science, Vol. ii., Part 1, 1888. *The University.*
- VIENNA—Anthropologische Gesellschaft in Wien. Mittheilungen, Band xv., N.F. Band v., Heft 4, 1885; Band xvii., N.F. Band vii., Heft 3 and 4, 1887. *The Society.*
- K. K. Central Anstalt für Meteorologie und Erdmagnetismus (Officielle Publication) Jahrgang 1886, Neue Folge, Band xxiii. *The Institute.*
- K. K. Geologische Reichsanstalt. Verhandlungen, Nos. 7 and 8, 1888. *The "Reichsanstalt."*

MISCELLANEOUS.

(Names of Donors are in *Italics*.)

- Cassino, (S. E.)—*The International Scientists' Directory*, 1888. *H. G. A. Wright, M.R.C.S.E.*
- Liversidge, A., M.A., F.R.S.—*The Minerals of New South Wales, &c.* *The Author.*

Tebbutt, John, F.R.A.S.—Observations of Comet α 1888.
On the Difference of Longitude between Mr.
Tebbutt's Observatory, Windsor, N.S.W., and the
Government Observatories at Sydney and
Melbourne.

The Author.

Trübner's *American, European, and Oriental Literature Record*,
New Series, Vol. ix., Nos. 1 and 2, 1888.

The Publishers.

WEDNESDAY, 5 SEPTEMBER, 1888.

A Conversazione was held in the Great Hall of the University, under the management of a Committee composed of the President, Sir Alfred Roberts, H. C. Russell, B.A., F.R.S., one of the Vice-Presidents, the Hon. Secretaries, Prof. Liversidge, M.A., F.R.S., and F. B. Kyngdon, and Messrs. Charles Moore, F.L.S., P. R. Pedley, Dr. Leibius, M.A., Prof. Threlfall, M.A., and Prof. Warren, M. Inst. C.E.

The Hall and the approaches were tastefully and artistically decorated with flags, shields, and festoons of greenery. Mr. Charles Moore, Director of the Botanic Gardens kindly furnished a supply of palms, ferns and rare pot-plants.

The Physical Laboratory was thrown open, and experiments were conducted by Prof. Threlfall and Mr. John F. Adair, also the Medical School of Prof. Anderson Stuart and the Mechanical Laboratories and workshops, where the large testing machine was exhibited in work by Prof. Warren.

The Macleay Museum and the various Lecture Rooms were also thrown open to the guests.

Mr. F. Morley presided at the organ, and select pieces were played at intervals.

The number of guests present was about 1,500, the unusually large gathering being due to the fact that invitation cards had been issued to the members of the Australian Association for the Advancement of Science, the Inaugural Meeting of which had just closed.

His Excellency Lord Carrington G.C.M.G. was unable to attend through absence from town, but the Premier Sir Henry Parkes, K.C.M.G., and party, and various members of the Ministry and of both Houses of Parliament were present.

LIST OF EXHIBITORS.

Brindley, Thomas—Microscope showing Crystals under Polarized Light.

Collie, Rev. R., F.L.S.—1. Microscope and objects. 2. Fossils from the Hunter River Valley. 3. Specimens of Ore from Victoria, Queensland, and New South Wales. 4. Mounted Ferns from the New Hebrides, New Zealand and New South Wales.

- Cox, Hon. G. H., M.L.C.—1. Silver Ore from Mount Stewart Mine, Denison Town. 2. Fossil plant.
- Cox, James C., M.L.C.,—1. Collection of Water Colour paintings of Australian Butterflies. 2. Photographs of Australian Birds.
- Cunningham, J. E.—Two Caligraph (Typewriters), early pattern and modern pattern.
- Deane, H., C.E.—1. Apparatus for testing the Deflection of Girder Bridges. 2. Microscope shewing *a*. Palate of *Buccinum undulatum*. *b*. Palate of Black Slug.
- Du Faur, E., F.R.G.S.—1. Three models of Arabesque work from the "Alhambra," Granada, Spain. 2. Copy of Line Engraving in silk—Ladies' work of the last century.
- Edmunds, P. J.—1. The immersion paraboloid illuminator, invented by Dr. James Edmunds of London, intended to give an all-round dark back ground illumination with the highest powers. Shown on the Ross Microscope stand belonging to the Royal Society. Microscope showing objects *a*, Diatoms. *b*. Podura Scale. 2. *a*. Foraminifera from a deep sea sounding off the West Coast of Australia. *b*. Grains of Gold. *c*. Young oyster shells. *d*. Feather of Sugar-bird.
- Elkington & Co.—1. Copy of the famous Milton Shield "Paradise Lost," executed by M. Morel-Ladeuil, cost of the original £6,000. 2. Copy of "Pompeian Lady" Plaque by the same artist, cost of original £1,500. 3. Plaque Shakesperian "Much Ado about Nothing" and "Merchant of Venice," "Perseus," "Prometheus," "Fame," "Time," "Truth," "Fiction." 4. Fine Art Italian Jug on stand, richly chased with classical figures in high class repoussé. 5. Three Ivory Tusk Tankards, richly carved. 6. Silver Jug and two Beakers, decorated, hand painted enamel, purchased for the Wagga-Wagga Cup, 1888. 7. Selection of Indian Copper Salvers, native workmanship. 8. Group of real bronze Horses on pedestal, fac-simile of the Silver group for the Melbourne Cup, 1888.
- Gibbs, J. B.—Planograph.
- Gilliat, H. A.—Plans and Maps in connection with Water Conservation as follows :—(A.) From First Report of Water Commission.—1. Map showing Drainage Areas of New South Wales. 2. Diagrams comparing plain with hilly portions of river basins. 3. Map of the district including the Barwon, Warrego and Paroo. (B.) Second Report of the Water Commission.—1. Map showing irrigation work in the County of Rodney, Victoria. 2. Map showing the work of the

Gilliat, H. A.—*Continued.*

Wimmera United Waterworks Trust. (C.) Third Report of the Water Commission.—1. Large plan of the Murray and Murrumbidgee, showing proposed Canal. 2. Diagram showing the discharges of the Murray and Murrumbidgee from 1879 till 1886. (D.) General plan of the work recently proposed for the irrigation of the Western Wimmera District.

Haulet, W. M., F.C.S.—Pieces of Cretone containing arsenic.

Hardy Brothers—Musical Tubes.

Hargrave, Lawrence—1. Experimental Model of a Flying-machine &c., driven by india rubber springs. 2. Compressed air-engine and wings for a Flying-machine. 3. Petroleum spirit vapour engine and wings for a Flying-machine. 4. A Richard's Indicator for these engines.

Haswell, W. A., D.Sc., M.A.—Microscopical objects, shown by electric light.

Houison, Dr. A., B.A.—Copy of "Breeches Bible" printed at Edinburgh, A.D. 1576.

Josephson, J. F., F.G.S.—1. New Binocular Microscope. 2. Specimens of Roman and Florentine Mosaic. 3. Commentary of Martin Luther upon St. Paul's Epistle to the Galatians, London, A.D. 1580.

Liversidge, Prof., M.A., F.R.S.—1. Two metal trays made of Japanese alloys. 2. Mokumi or wood grain alloy, made by soldering together strips of differently coloured metals and alloys and drilling or cutting holes and trenches of various shapes and sizes; they are then hammered until the holes disappear, on rubbing down and polishing the laminae appear as circles and curves; pickled to bring out the different layers. 3. A Series of coloured photographs of Japan and carved ivories, &c. 4. Exhibition of the use of wooden batea. 5. Rock section cutting and polishing machine at work. 6. Three microscopes. 7. Specimens of Erythrite, (cobalt bloom) and smaltine with molybdenite, from Carcoar.

MacDonnell, S.—Microscope, showing *Melicerta ringens* (the brick-making rotifera).

Mackrell Mills & Co.—The "Hall" Typewriter.

Makin, G. E.—1. Fossils from the coal measures at Berrima. 2. Queen Anne's Prayer Book, A.D. 1607. 3. Copies of "Flying Post," newspaper A.D. 1697, and "Kentish Gazette," A.D. 1798. 4. Old prints from the 'Temple of Winds,' Athens.

Minister of Public Works.—Two albums of photographs, and 57 loose photographs—Views and Government Buildings in New South Wales.

- Poate, Frederic.—1. Vulgate MDXL. 2. Subtense Theodolite . specially manufactured by Troughton and Simms.
- Quaife, W. F., M.B. &c., Univ. *Glas.*—Two Crayon Studies of Medieval stone carvings from Thronthiem Cathedral. (Original).
- Quodling, W. H.—Eleven photographs, (large).
- Ramsay, E. P., LL.D., &c.—1. Two cases of Humming Birds. 2. Gould's Birds of New Guinea.
- Rigg, T. S. J., B.A.—Microscope showing "Section of Human Scalp through hair bulbs."
- Roth, Reuter E., M.R.C.S.E.—1. Series of photographs of free gymnastic exercises suitable for girls. 2. Spirometer. 3. Dynamometer. 4. Old Sun-dial.
- Russell, H. C., B.A., F.R.S.—Recording Electrical Thermometer &c.
- Selge, Norman, M. Inst. C.E.—Model of a Double Screw Ferry Steamer, recently patented. Special features—1. In order to get the greatest beam for stability, combined with the greatest depth for immersion of the propellers, and a small displacement only sufficient for deck walls; the bilges are cut entirely away and the hull presents a triangular section at every frame. 2. The triangular section makes an immensely strong structure to withstand the concussion against wharfs, and is cheap to build. 3. The triangular section allows of a series of air cells being enclosed between longitudinal and transverse bulkheads in the wings. 4. The upper decks are detachable, and float off as rafts in case of collision or sinking of the vessel.
- Sinclair, Sutherland.—1. Two revolving albumns—made in Sydney, of Australian wood, "Cypress Pine," a species of *Frenella*—containing view of Scottish Scenery. 2. One glass case, group of Scottish Birds. 3. Case containing coins. 4. Model of Catamaran with four paddles, Brazil. 5. Facsimile of Death Warrant for King Charles I. 6. Facsimile of Bond of the Covenant sworn by the Ministers of the Associate Presbytery at Stirling, 1745. 7. Russian Passport for S. Sinclair to go from Cronstad to St. Petersburg, Oct. 1825. 8. Cabinet of Miscellaneous Curiosities, containing Piece of wood destroyed by the Teredo, Gulf of Mexico. Sea Horse, *Hippocampus erinaceus*. Pipe Fish, *Syngnathus acus*, Firth of Clyde. Poison Bean used in Trial by Ordeal, Old Calabar. Cow Fish, *Ostracion quadricornis*, Gulf of Mexico. Sucking Fish, *Lepadogaster gounii*. Lizard, *Zootoca vivipara*, Arran, Scotland. Model of Skin Canoe used by the Esquimaux Greenland, (the canoe used by the women is of a different form). Model of Esquimaux Sledge and Dog. Model of

Sinclair, Sutherland.—*Continued.*

Esquimaux Snow Kife, made from Walrus Tusks. Jet Penholder. Watch found in the stomach of a Shark in Port Jackson. Hand of an Egyptian Mummy. Bracelet from Pompeii. Diamond Drill cores, (small pieces only) Astoria Works, "Hell Gate." New York. Ivory Nut, *Sagas* sp., young fruit of Sago Palm, South Sea Islands. Monkey Nut, Souati or Butter Nut, *Caryocar tomentosum*, West India. Necklace made from Melon seeds on the Island of St. Helena. 9. An old Bible from the times of the Scottish Covenanters. 10. Old book, "The Psalms of David, Aberdene, 1633," with MS inscription. 11. Stereoscope with views of New York, and a few of New South Wales, &c. 12. Silver Leaves of South Africa, *Leucadendron argenteum*. 13. Kaleidoscope.

Stephen, Prof. W. J., M.A.—1. *Notochely's costata*, Flinders River, Queensland. 2. *Ottelia praterita*, F.v.M., Parramatta River, New South Wales. 3. *Mastodonsaurus robustus*, Trias, Europe. 4. *Platycephalus wilkinsonii*, Hawkesbury Sandstone, Gosford.

Stott & Hoare.—The Remington Typewriter.

Stuart, Professor Anderson, M.D.—Collection of Anatomical models, &c.

Technological Museum.—1. Papier-maché model of Fuchsia plant. 2. Papier-maché model of Pea plant, with pods &c., complete. 3. Australian Rubies, cut and uncut. 4. Model of hen egg, enlarged to size of Moa egg, with four sections showing the various stages of incubation. 5. Full size model of the celebrated Strauss tankard. 6. Richly illustrated coloured works, viz.—Musical Instruments, historic, rare and unique; Jeypore enamels; Fifteenth Century Italian Ornament; Thirty small portfolios of Indian, Persian, and Spanish art manufactures. 7. Two volumes of fine and very interesting photos:—Madras art ware; Famous monuments of Central India.

Threlfall, Prof., M.A.—Physical apparatus, and experiments in Laboratory.

Trebeck, P. C.—1. Four enlargements on Eastman's Bromide Paper from half plate negatives, viz., Hay's Bend, Mount Wilson; Road on crest, Mount Wilson; Turn in Zigzag, Mount Wilson; H.M.S. "Calliope." 2. Photo of group of statuary on opal.

University Cricket Club.—The "Gardiner" Trophy Cup.

Warren, Prof., M.Inst.C.E.—Collection of Educational appliances.

- Whitelegge, Thomas—1. Microscope with series of slides illustrating the Micro-Fauna and Flora of Australia. 2. Hydroid Zoophyte from Coogee Bay.
- Whitton, John, C.E.—1. Photograph of the Forth Bridge. 2. Photographs of the Foundations of the Forth Bridge. 3. Coloured Drawing of proposed Railway Station, Sydney.
- Wilshire, F. R., P.M.—1. Collection of New South Wales Gems. 2. Model of Anti-rattler and Buggy-shaft Coupler combined.
- Woods, Rev. J. E. Tenison-, F.G.S., &c.—Curios from Japan, Java, the Philippine Islands, &c., viz., 1. Collection of conical shells from Philippine Islands. 2. Pair of large shells with opercula, (*Turbo marmoratus*) Philippines. 3. Four marble balls with stands for three, ring for fourth, Jeddo. 4, 5. Two pairs of Japanese bronze vases. 6. Pair bronze vases with tray, Japanese, stained yellow. 7. Two Gourds used for Saki bottles, Japanese. 8. Three bronze articles, Temple furniture. 9. Nine metal models of instruments, insects, &c. 10. Models of Javanese implements. 11. Two Japanese Kakimonos. 12. Three China figures of gods. 13. Sixteen clay figures. 14. Twenty-five drawings of Singapore flowers. 15. Metal model of Japanese house, with three crabs. 16. Thirty Japanese drawings on silk. 17. Two clay statues of gods. 18. Box of insects, Cocoa nut destroyers, Malacca. 19, 20. Two clay gods. 21. Five specimens of ivory and marble balls. 22. Statue of Japanese pedlar, drunk. 23. Two statues of goddesses. 24. Statue of Bentang. 25. Book of Japanese Fish. 26. Two Japanese lithographs. 27. Marble specimens (26 pieces), and small clay pot with lid, Japanese. 28. Two statues old men, clay. 29. Seventeen specimens marble and clay, Japan. 31. Large mask of Otafo-ku, Domestic Goddess. 32. Painted shell. 33, 34. Four Swords, Japanese and Malay. 35. Small sword with stand, Japanese. 36. Three Japanese gongs. 37. Two clasps for fastening a kimono and a nitsuke, made of the horns of a goat, antelope, worn as a charm in the belt, Japanese. 38. Bottle of ash from Krakatoa, Java.
- Wright, H. G. A.; M.R.C.S.E.—1. Twenty-four photo-micrographs. 2. Six enlarged photo-micrographs. 3. Microscope and objects. 4. Six photo-micrographs by Thomas Francis, Esq.

CENSUS OF THE FAUNA OF THE OLDER TERTIARY OF AUSTRALIA.

By Professor RALPH TATE, F.G.S., F.L.S., &c.

[*Read before the Royal Society of N.S.W., October 3, 1888.*]

IN 1878, Mr. R. Etheridge, Junr., published a very useful compilation—"A Catalogue of Australian Fossils," but at that date so very few species of the Older Tertiary Period were diagnostically known that his enumeration very inadequately represents its rich fauna. Up to that time no class or large group had received much attention at the hands of the monographer, save the corals and foraminifera, though a fair proportion of the echinoids had been described by Professors Laube and M. Duncan; but in the past few years, the palliobranchs, lamellibranchs and part of the gastropods have been elaborated by myself, and the polyzoa by Mr. A. Waters; whilst the Tasmanian fauna has been fairly worked out by the Rev. J. E. Tenison-Woods, Mr. R. M. Johnston and myself; the coral-fauna has been largely supplemented by the Rev. J. E. Tenison-Woods; and miscellaneous additions have been made by Professor McCoy, the Rev. J. E. Tenison-Woods and the writer.

In most classes, a very large number of the actually known species has been now diagnosed; but the gastropods, which constitute about one-half the fauna, are for the most part undescribed.

In the appended table are given the names of all the genera known to occur in the Older Tertiary deposits, and the figures in the column indicate the number of species represented by each genus. The table is compiled from the sources of information already alluded to, and largely supplemented by my collections from the chief fossiliferous localities in South Australia, Victoria and Tasmania, most of which I have visited. In this connection my thanks are due to Mr. R. M. Johnston for the gift and loan of many Table Cape species, to Mr. J. Dennant for additions to my Muddy Creek collection, to Mr. Gregson for the gift of a large series of Gippsland species, to the Rev. J. E. Tenison-Woods for a gift of type examples of the species described by him from Muddy Creek in the Proceedings Linnean Society, New South Wales, Vols. iii. and iv. To Sir James Hector and Professors Haast and Hutton I am under obligation for an extensive suite of species from the Tertiary deposits of New Zealand, which has been

of great service in elaborating and in working out the relationships of the Australian species. To Mr. Walter Howchin, F.G.S., I am indebted for a census of the genera of Foraminifera, additional to those already published chiefly determined from material obtained from the Adelaide bore and Muddy Creek. It is very generous of him to allow me to anticipate the announcement of many interesting genera in our Tertiary deposits, previously unknown as fossil; I trust that the results of his labours in this field of investigation will not long be withheld from us.

THE CHIEF AREAS AND LOCALITIES OF THE OLDER TERTIARY MARINE DEPOSITS ARE:—

SOUTH AUSTRALIA.

1. Bunda Plateau and cliffs of the Great Australian Bight, extending to lat. 32° S.
2. St. Vincent Gulf:—East coast of Middle Yorke Peninsula, Adelaide, Aldinga Bay, and Nepean Bay, Kangaroo Island.
3. Gorge of the River Murray from Overland Corner to Lake Alexandrina, and well sinkings on the Murray Plain adjacent to the river.
4. Mount Gambier embracing Narracoorte, the Glenelg River and Portland.

VICTORIA.

5. Muddy Creek, Hamilton.
6. Cape Otway, Gellibrand River, and Jan Juc.
7. Corio Bay and Waurin Ponds, Geelong.
8. Bacchus Marsh; Moorabool River.
9. Balcombe Bay, Mordialloc, Cheltenham and Flemington, Port Philip.
10. Gippsland Lakes.

TASMANIA.

11. Table Cape, North-west Coast, the most Southern station in lat. 41° S.

The area, over which patches of marine Older Tertiary extend, is comprised within latitudes 41° and 32° and longitudes 148° and 128°, and probably so far as 123°. The marine beds of this age appear for the most part to fringe the present coast line and except the more northerly parts of the basin of the Lower Murray River and the interior of the Bunda Plateau, no fossiliferous section is beyond 50 miles from the sea shore; and judging by their distribution, thickness and altitudes of sites they appear not to have extended much beyond their present limits.

The greater mass of the formation does not attain to a greater elevation than 200 feet above sea level; but in the Adelaide bore was proved for a depth of 250 feet below sea level, and on the Bunda Plateau to about 500 feet. For the most part the secular elevation of the Older Tertiary sea-bed has been of small amount

and uniform ; at the Great Australian Bight the maximum elevation on the coast is 250 feet, (incorrectly given in our maps at 600 feet), with an increasing elevation inland for a distance of 80 miles ; the Muddy Creek section is 410 feet above sea level ; at Gawler it is about 400 feet declining south to Aldinga Bay at sea level in a length of 50 miles. Catyclismal disturbance must account for the presence of fossiliferous beds of this age in the Encounter Bay District at elevations above 600 feet.

SUBDIVISIONS OF THE OLDER TERTIARY.—Where the series is fully developed, two distinct periods are represented separated by a most decided palæontological break, and in some sections by a stratigraphical one. The fossils of the older period viewed in their relation to the living fauna of the same area should be called Lower Eocene, if it be permissible to apply European terminology, whilst the younger period may be called Miocene.

The chief fossiliferous localities of the Eocene are :—

- (1) Chalk rock and polyzoal limestone of the Great Australian Bight.
- (2) Inferior beds at Aldinga Bay, and River Murray Cliffs.
- (3) Mount Gambier beds ; lower beds at Muddy Creek.
- (4) Cape Otway beds.
- (5) Spring Creek, Corio Bay and Schnapper Point, † Cheltenham.
- (6) Table Cape, Tasmania.

I do not attempt to correlate the sections ; though viewed separately they offer very dissimilar lithological and palæontological characters which might seem to indicate so many different horizons, but it is not improbable the differences in the fossil assemblages at different localities may have arisen from peculiar petrographic and bathymetric conditions.

Of the Miocene are :

- (1) Marbles of the Great Australian Bight.
- (2) Oyster beds Aldinga Bay and River Murray Cliffs.
- (3) Upper beds at Muddy Creek.
- (4) Moorabool River, † Cheltenham.
- (5) Gippsland beds.
- (6) Turritella beds, Table Cape.

Apart from the greater affinity specifically and generically which the Miocene presents to the recent fauna, its deposits are characterised by the absence or paucity of Palliobranchs, Echinoids, Polyzoa, Corals and Foraminifera ; and partly in consequence of this, the sediments are less calcareous being for the most part clays or sands.

No marine deposits are encountered in ascending the geological scale till those of Pleistocene age are reached ; the hiatus being partially occupied by the Mammaliferous Drifts, which may be classed homotaxially as Pliocene.

RELATION OF THE OLD TERTIARY FAUNA TO THAT OF SOUTHERN AND EAST-TEMPERATE AUSTRALIA.—The fauna of the Old Tertiary has been replaced over much the same geographical area by that extant on the Southern and South-eastern shores of Australia, and comparisons between the two permit of legitimate deductions.

Viewed as a whole the Old Tertiary fauna is closely related generically to that existing in the same area ; but a few conspicuous Australian genera are not at all, or poorly represented as :—*Cominella*, *Phasianella*, *Elenchus*, *Clanculus*, *Risella* among Gasteropods ; *Solemya* and *Soletellina* among Conchifers ; and *Amblypneustes* and *Holopneustes* among Echinoderms.

The peculiar Australasian generic types, *Zemira*, *Pellicaria*, sections *Amoria* and *Volutoconus* of *Voluta*, *Crossea*, *Trigonia*, *Chamosirea*, *Magasella*, *Linthia*, and *Eupatagus* are equally well or better represented by fossil as living species.

On the other hand, *Harpa*, *Cassidaria*, *Eburna*, *Rapana*, and *Amusium* among Molluscs, and *Seriatopora*, *Plesiastrea*, *Heliastraea*, *Antillia*, *Cycloseris*, *Placotrochus* among corals, and several species of Foraminifera are tropical.

A further departure from the prevailing Australian facies is the presence of genera extinct in the Australian region—as *Pleurotomaria*, *Melanopsis*, *Sequenzia*, *Cucullaea*, *Thecidium*, *Rhynchonella*, *Terebratella* and some corals ; and also by the presence of genera unrepresented in living creation. Of these *Aturia*, *Conorbis*, *Mesostoma* (if distinct from *Trichotropis*), *Vaginella*, *Limarca*, *Dimya*, *Protocardium*, *Micraster*, *Holaster*, *Graphularia*, *Nummulites*, and the Zeuglodont Cetaceans are alliances with the Older Tertiary of the Northern Hemisphere ; whilst *Pseudovaricia*, *Dennantia*, *Elismope*, *Zenatiopsis*, *Capistrocardia* among Molluscs, and *Notocyathus*, *Bistylia*, *Trematotrochus*, *Conosmia*, *Cyathosmia* and *Palaeoseris* among corals are peculiar to the Older Tertiary of Australia.

The numbers of testaceous species in each class, except Palliobranchiata, show very close agreement with those of the Provincial faunas of New South Wales, Tasmania, and South Australia as set forth in the following table :—

Recent Fauna of—				Cephalopoda.	Gastropoda.	Lamelli-branchiata.	Pteropoda.	Palliobranchiata.	Total.
New South Wales...	...	...	...	5	510	233	10	9	767
Tasmania ...	...	...	...	4	386	141	...	5	536
South Australia ...	...	...	...	4	387	177	...	6	574
Older Tertiary Fauna of Australia...				3	684	240	5	34	966

The percentage numbers of the two largest classes, Gastropoda and Lamellibranchiata are as follows :—

	Gastropoda.		Lamellibranchiata.	
New South Wales	68.64	...	31.36	
Tasmania	73.2	...	26.8	
South Australia	68.1	...	31.9	
Mean	69.3	...	31.7	
Older Tertiary of Australia	74.8	...	25.2	

The high ratio of the Gastropods to the Lamellibranchs in the Old Tertiary Fauna is not unexpected, and when the Gastropods shall have been more fully elaborated the differences will be intensified.

It would have been desirable in our comparison of the living and fossil faunas, that the recent species of our provincial lists had been concreted ; but this is not possible until the claims of a very large number of Tasmanian species to rank as peculiar have been firmly established.

The comparative richness in species of Palliobranchs, corals and echinoids and in a less degree of polyzoa, is a distinguishing feature between the Recent and Old Tertiary faunas of Australia. The numerical strength of the Palliobranchiata is paralleled in the Italian Eocene, and the generic variety in the Echinodermata by the Maltese Miocene and the Scindian Nummulitic.

The specific relations are few, except among the polyzoa, entomostracans and foraminifera, so far as the determinations have been made. In Vertebrata and Cephalopoda there are none; less than a dozen of Gastropoda, and not many more of Lamellibranchiata, in both classes the specific identities are more or less protean species. There is at least one living species of Palliobranchiata, and nearly one-half of the Polyzoa survive to the present day, though of the Cyclostomatous order there are only three species in recent creation out of a total of 22, whilst a few antedate to Cretaceous. The echinoderms are all extinct, though *Schizaster ventricosus* and *Echinanthus testudinarius* have erroneously been quoted. Corals have three or four identities, one only Australian ; and all, or nearly all, the foraminifers as might be expected are living, the Eocene *Nummulites* being the most marked exception.

The total living species in the classes indicated in the accompanying list is 31, which out of a total of 1046, represents only 3 per cent. Of the 31, 14 are found in the Lower Series or Eocene, whilst 21 are actually known in the Upper Series or Miocene and by inference the additional 10 which pass up from the Eocene though yet undiscovered in the Miocene. Complete lists of the fauna of each subdivision of the Older Tertiary have

not yet been prepared, but on a rough estimate, the percentage of living species in the Eocene does not exceed one, and in the Miocene may amount to 10.

LIST OF OLD TERTIARY SPECIES HAVING LIVING IDENTITIES.
(Polyzoa, Entomostraca, and Foraminifera omitted.)

	Australian Tertiary.		Recent.
	Eocene.	Miocene.	
<i>Triton Quoyi</i> , <i>Reeve</i>	*	Extratropic Australia.
<i>Voluta undulata</i> , <i>Lamk.</i>	* †	Extratropic Australia.
<i>Crepidula monoxylon</i> , <i>Lesson</i>	* †	New Zealand; Victoria.
<i>Capulus subfuscus</i> , <i>Sow.</i>	*	Extratropic Australia.
<i>Amalthea australis</i> , <i>Lamk.</i>	*	Australia.
<i>Hipponyx antiquatus</i> , <i>Lin.</i>	*	Australia; Indian Archipelago
<i>Nerita melanotragus</i> , <i>Smith</i>	*	Australia.
<i>Crossea labiata</i> , <i>Woods</i> ...	*	?	Tasmania.
<i>Fissurella nigrita</i> , <i>Sow.</i>	*	Extratropic Australia.
<i>Dentalium lacteum</i> , <i>Desh.</i>	?	Indian Seas.
<i>Cadulus acuminatus</i> ,	*	South Australia.
<i>Ostrea hyotis</i> , <i>Linn.</i>	?	Indian Seas.
<i>Placunanomia ione</i> , <i>Gray</i>	*	Southern Australia; New Zealand.
<i>Nucula antipodum</i> , <i>Hanley</i>	* †	Tasmania.
<i>Leda crassa</i> , <i>Hinds</i>	* †	Australia.
<i>Limopsis aurita</i> , <i>Sacchi</i>	*	European.
„ <i>Belcheri</i> , <i>Ads. & Rv.</i>	*	Southern Australia; South Africa.
<i>Pectunculus laticostatus</i> , <i>Quoy</i> ...	*	?	New Zealand.
<i>Trigonia acuticostata</i> , <i>McCoy</i>	*	Victoria.
<i>Lucina quadrisulcata</i> , <i>D'Orb.</i>	*	Indian Seas; Australia; New Zealand; &c.
<i>Mytilus Chorus</i> , <i>Molina</i>	* †	Southern Australia; New Zealand.
<i>Chamostrea albidia</i> , <i>Lamarck</i> ...	*	*	Southern Australia; New Zealand.
<i>Tellina lata</i> , <i>Quoy et Gaimard</i>	*	Malay Archipelago.
<i>Venerupis crenata</i> , <i>Lamarck</i>	* †	Extratropic Australia.
<i>Corbula scaphoides</i> , <i>Hinds</i>	* †	E. Indies; Australia.
<i>Saxicava arctica</i> , <i>Lin.</i>	?	Cosmopolitan.
<i>Rhynchonella squamosa</i> , <i>Hut.</i> ...	*	?	Southern Ocean.
<i>Flabellum Candeanum</i> , <i>E. & H.</i>	?	China.
„ <i>distinctum</i> , <i>E. & H.</i>	?	China.
<i>Deltocyathus italicus</i> , <i>E. & H.</i>	?	West Indies.
<i>Sphenotrochus variolaris</i> , <i>W.</i>	?	New South Wales.

† The age of the beds yielding these is doubtful, it may be Pleistocene.

SPECIFIC RELATIONS WITH OTHER TERTIARY AREAS.—I. *New Zealand.* The accompanying list contains the names of 45 species common to the Older Tertiary of the two areas, from which may be gathered that our Eocene species are largely prevalent in the Oamaru Series of Hutton (Cretaceo-Eocene of Hector), and that our Miocene species are best represented in the Pareora Series.

The community of species is absolutely small and is very much less than pertains to the recent faunas; thus the number of living testaceous mollusca in the New Zealand area migrants from Australia is as much as 18·8 per cent. of the whole; whilst the Australian Old Tertiary species occurring in corresponding deposits in New Zealand is only 3·45 per cent. of the Australian fauna: or to express the relationship in terms of the New Zealand Old Tertiary fauna, 36 of a total 288, or 12·8 per cent. are common to New Zealand and Australia. These data are not of sufficient value to bring the subdivisions of the Older Tertiary strata of the two areas into close relationship.

TERTIARY FOSSILS COMMON TO AUSTRALIA AND NEW ZEALAND:

	Eocene.	Miocene	Pliocene Series.	Quaternary Series.
<i>Carcharodon angustidens</i> , Ag... ..	*	*
„ <i>megalodon</i> , Ag.	*	*
<i>Aturia zic-zac</i> , Sowerby... ..	*	...	*	*
<i>Typhis McCoyii</i> , T.-Woods	*	...	*	...
<i>Ancillaria hebera</i> , Hutton	*	...	*	*
<i>Terebra catenifera</i> , Tate	*	*	...
<i>Surcula Haastii</i> , Hutton	*
<i>Melanopsis Pomahaka</i> , Hutton	*	*	...
<i>Turritella Aldingæ</i> , Tate	*	...	*	*
<i>Natica Hamiltonensis</i> , T.-Woods	*	*	*	*
„ <i>solida</i> , Hutton	*	*	*
<i>Pleurotomaria Tertiaria</i> , McCoy	*	*	...
<i>Entalis Mantelli</i> , Zittel	*	...	*	*
<i>Gryphæa tarda</i> , Hutton	*	*
<i>Placunamonia sella</i> , Tate	*	*	...	*
„ <i>ione</i> , Gray	*	*	*	...
<i>Pecten Zitteli</i> , Hutton	*	*
„ <i>Hochstetteri</i> , Zittel	*	...	*	*
„ <i>Yahlensis</i> , T.-Woods	*	*
„ <i>polymorphoides</i> , Zittel... ..	*	...	*	*
<i>Lima Bassi</i> , T.-Woods	*	*
<i>Limopsis insolita</i> , Sowerby	*	*	*	...
„ <i>aurita</i> , Broch.	*	*	*	*
<i>Pectunculus laticostatus</i> , Quoy	*	*
<i>Perna Zealandica</i> , Hutton	*	*
<i>Chamostrea albida</i> , Lamarck	*	?	*	...
<i>Lucina quadrisulcata</i> , D'Orb.	*	*	...
<i>Trigonia acuticosta</i> , McCoy	*
„ <i>semiundulata</i> , McCoy	*	...	*	...
<i>Dosinia Grayii</i> , Zittel	*	*	...
<i>Panopæa orbita</i> , Hutton	*	*
<i>Saxicava arctica</i> , Linn.... ..	*	?	*	...
<i>Teredo Heaphyi</i> , Hutton	*	...	*	...
<i>Waldheimia insolita</i> , Tate	*	*
<i>Terebratulina Scouleri</i> , Tate	*	*
<i>Terebratella furculifera</i> , Tate	*	*
„ <i>Aldingæ</i> , Tate	*	*
<i>Magasella Woodsiana</i> , Tate	*	*

	Eocene.	Miocene.	Pliocene Series.	Oamaru Series.
<i>Rhynchonella squamosa</i> , Tate	*	p	p	*
<i>Isis dactyla</i> , T.-Woods	*	*
<i>Graphularia senescens</i> , Tate	*	*
<i>Cidaris Australiæ</i> , Duncan	*	*
<i>Echinus Woodsii</i> , Laube	*	*
<i>Pericosmus compressus</i> , McCoy	*	*
<i>Pentacrinus sellatus</i> , Hutton	*	*

N.B.—Polyzoa and Foraminifera are omitted.

II. *Other Tertiary Areas.* *Siphonalia reflexa* and *Limopsis insolita* are common to Australia and Chili.

Carcharodon angustidens, *C. megalodon* and other sharks, and *Aturia zic-zac* were cosmopolitan in Eocene times.

Xenophora agglutinans and *Nummulites variolaris* are common to the Eocene beds of the Hampshire and Paris Basins and Australia.

LIST OF GENERA AND NUMBER OF SPECIES OF THE INVERTEBRATE FAUNA OF THE OLDER TERTIARY OF AUSTRALIA :—

Class MAMMALIA. (Order Cetacea.)				Family Tritonidæ.	
<i>Squalodon</i>	1			<i>Triton</i>	19
<i>Zeuglodon</i>	1			<i>Epidromus</i>	7
<i>Physætodon</i>	1			<i>Ranella</i>	1
<i>Ziphius</i>	1				—27
<i>Balanoptera</i> ?	1			Family Fusidæ.	
<i>Cetotolithes</i>	4—9			<i>Fusus</i>	20
Class REPTILIA.				<i>Fasciolaria</i>	8
<i>Crocodylus</i>	1			<i>Peristernia</i>	15
Class PISCES.				<i>Pisania</i>	5
<i>Lamna</i>	3			<i>Pseudovaricia</i>	1
<i>Oxyrhina</i>	1			<i>Sipho</i>	4
<i>Otodus</i>	1			<i>Siphonalia</i>	5
<i>Galeocerdo</i>	1			<i>Dennantia</i>	2
<i>Carcharodon</i>	2			<i>Tudicula</i>	3
<i>Mylobates</i>	1			<i>Leucozonia</i>	3
<i>Cestracion</i>	1			<i>Cominella</i>	5
<i>Atopomycterus</i>	1			<i>Phos</i>	6
<i>Pagrus</i>	1—12			<i>Cantharus</i>	1
Class CEPHALOPODA.				<i>Eburna</i>	1
<i>Nautilus</i>	1			<i>Zemira</i>	1
<i>Aturia</i>	1				—80
<i>Sepia</i>	1—3			Family Nassidæ.	
Class GASTROPODA.				<i>Nassa</i>	3
Family Muricidæ.				Family Volutidæ.	
<i>Murex</i>	29			<i>Voluta</i>	36
<i>Typhis</i>	6			<i>Lyria</i>	2
<i>Trophon</i>	8			<i>Mitra</i>	12
<i>Purpura</i>	1			<i>Turricula</i>	14—64
<i>Nicinnula</i>	1			Family Marginellidæ.	
<i>Bapana</i>	1			<i>Erato</i>	3
<i>Vitularia</i>	1—47			<i>Marginella</i>	15—18

Family Olividae.				Family Sculariadae.			
Olivella	...	...	1	Scalaria	...	...	10
Oliva	...	...	2	Cirsotrema	...	...	8
Ancillaria	...	...	9	Crossea	...	...	4
Harpa	...	...	8				—22
			—20	Family Neritidae.			
Family Columbelloidae.				Nerita	...	...	1
Columbella	...	...	26	Family Trichotropidae.			
Family Cancellariidae.				Mesostoma	...	...	2
Cancellaria	...	...	13	Family Turritellidae.			
Family Terebridae.				Turritella	...	...	8
Terebra	...	...	8	Torcula	...	...	2
Family Pleurotomidae.				Mesalia	...	...	1
Pleurotoma	...	...	18				—11
Mangilia	...	...	18	Family Vermetidae.			
Clathurella	...	...	18	Siliquaria	...	...	3
Daphnella	...	...	6	Vermetus	...	...	1—4
Borsonia	...	...	1	Family Eulimidae.			
Drillia	...	...	10	Eulima	...	...	3
Clavatula	...	...	4	Mucronalia	...	...	1
			—57	Leiostraca	...	...	2
Family Conidae.				Niso	...	...	1—7
Conorbis	...	...	1	Family Turbonillidae.			
Conus	...	...	12	Turbonilla	...	...	4
			—13	Mathilda	...	...	4
Family Strombidae.				Odostomia	...	...	5
Pellicaria	...	...	2	Syrnola	...	...	3
Struthiolaria	...	...	1—3				—16
Family Cypræidae.				Family Pyramidellidae.			
Ovula	...	...	1	Pyramidella	...	...	3
Cypræa	...	...	14	Family Littorinidae.			
Trivia	...	...	1	Littorina	...	...	2
Calpurna	...	...	1	Family Cerithiidae.			
			—17	Planaxis	...	...	1
Family Cassididae.				Alaba	...	...	1
Cassis	...	...	1	Cerithium	...	...	6
Semicassis	...	...	4	Bittium	...	...	4
Cassidaria	...	...	2	Ceritella	...	...	6
			—7	Cerithiopsis	...	...	9
Family Naticidae.				Triphoris	...	...	8
Natica	...	...	14	Potamides	...	...	3
Eligmope	...	...	1				—38
			—15	Family Rissoidae.			
Family Calyptræidae.				Rissolina	...	...	4
Sigapatella	...	...	6	Rissoa	...	...	12
Crepidula	...	...	4				—16
Hipponyx	...	...	2	Family Ampullaridae.			
Capulus	...	...	3	Ampullaria?	...	...	1
			—15	Family Truncatellidae.			
Family Onustidae.				Truncatella	...	...	1
Xenophora	...	...	1	Family Melanidae.			
Family Solariidae.				Melanopsis	...	...	1
Solarium	...	...	4	Family Liotidae.			
Torinia	...	...	1	Liotia	...	...	3
Adeorbis	...	...	1	Cyclostrema	...	...	5
Discohelix	...	...	1—7	Collonia	...	...	1—9

Family Rotellidæ.				Class SCAPHOPODA.			
Ethalia	...	...	2	Dentalium	...	...	3
Family Turbinidæ.				Entalis	...	...	4
Phasianella	...	...	3	Cadulus	...	...	2
Turbo	...	...	8	Class PTEROPODA.			
Carinidea	...	...	3	Vaginella	...	...	1
Imperator	...	...	6	Limacina	...	...	1
			-20	Creseis	...	...	3
Family Trochidæ.				Class LAMELLIBRANCHIATA.			
Trochus	...	...	20	Family Ostreidæ.			
Minolia	...	...	4	Ostrea	...	...	5
Gibbula	...	...	5	Gryphæa	...	...	1
Thalotia	...	...	3	Dimya	...	...	2
Elenchus	...	...	1	Family Anomiidæ.			
Diloma	...	...	4	Placunanomia	...	...	2
Trochocochlea	...	...	1	Anomia	...	...	1
Euchelus	...	...	4				-3
Clanculus	...	...	2	Family Pectenidæ.			
Bankivia	...	...	1	Pecten	...	...	19
Leiopyrga	...	...	2	Amusium	...	...	2
			-47	Hinnites	...	...	1
Family Haliotidæ.				Lima	...	...	5
Pleurotomaria	...	...	1	Limea	...	...	2
Sequenzia	...	...	1				-29
Scissurella	...	...	1	Family Spondyliidæ.			
Haliotis	...	...	4	Spondylus	...	...	2
			-7	Family Aviculidæ.			
Family Fissurellidæ.				Avicula	...	...	1
Fissurella	...	...	1	Meleagrina	...	...	1
Fissurellidæa	...	...	2	Vulsella	...	...	1
Emarginula	...	...	8	Pinna	...	...	2
Zeidora	...	...	1	Perna	...	...	1
			-12				-6
Family Patellidæ.				Family Mytilidæ.			
Acmsæa	...	...	2	Modiola	...	...	3
Family Chitonidæ.				Mytilus	...	...	6
Chiton?	...	...	1	Septifer	...	...	1
Family Philinidæ.				Lithodomus	...	...	1
Scaphander	...	...	2	Modiolaria	...	...	3
Family Tornatellidæ.				Crenella	...	...	1
Myonia	...	...	1				-15
Tornatina	...	...	1	Family Arcadæ.			
Buccinula	...	...	2	Nucula	...	...	6
Triploca	...	...	1	Leda	...	...	11
Ringuicula	...	...	1-6	Limopsis	...	...	4
Family Cylichnidæ.				Limarca	...	...	1
Cylichna	...	...	6	Pectunculus	...	...	6
Volvula	...	...	1	Arca	...	...	2
Utricula	...	...	1	Barbatia	...	...	7
			-8	Macrodon	...	...	1
Family Bullidæ.				Cucullæa	...	...	2
Bulla	...	...	1				-40
Family Umbrellidæ.							
Umbrella	...	...	1				
			684				

250 CENSUS OF THE OLDER TERTIARY FAUNA OF AUSTRALIA.

Family Trigoniidæ.				Family Mactridæ.			
Trigonia	...	...	4	Mactra	...	...	3
				Zenatiopsis	...	...	1
Family Unionidæ.							—4
Unio	...	...	2	Family Paphiidæ.			
				Anapa	...	...	1
Family Astartidæ.				Family Anatinidæ.			
Crassatella	...	...	6	Myadora	...	...	7
Carditella	...	...	5	Thracia	...	...	1
Cardita	...	...	13				—8
Mytilicardia	...	...	5	Family Corbulidæ.			
			—29	Corbula	...	...	3
Family Lucinidæ.				Nesera	...	...	3
Lucina	...	...	10				—6
Loripes	...	...	1	Family Saxicavidæ.			
Cryptodon	...	...	1	Saxicava	...	...	1
			—12	Panopæa	...	...	2
Family Ungulinidæ.				Capistrocardia	...	...	1
Diplodonta	...	...	1				—4
Sacchia	...	...	2	Family Solenidæ.			
			—3	Solen	...	...	1
Family Erycinidæ.				Solecurtus	...	...	3
Lepton	...	...	2				—4
Pythina	...	...	1	Family Pholididæ.			
Kellia	...	...	1	Barnea	...	...	1
Montacuta	...	...	1	Jouannetia	...	...	1
			—5				—2
Family Chamidæ.				Family Terebinidæ.			
Chama	...	...	1	Teredo	...	...	2
Chamostrea	...	...	1				
			—2	Family Gastrochænidæ.			
Family Verticordiidæ.				Humphreyia	...	...	2
Verticordia	...	...	2	Aspergillum	...	...	1
							—3
Family Cardiidæ.							—
Cardium	...	...	5				240
Protocardium	...	...	2				—
			—7	Class PALLIOBRANCHIATA.			
Family Veneridæ.				Family Terebratulidæ.			
Chione	...	...	9	Terebratula	...	...	4
Cytherea	...	...	5	Waldheimia	...	...	15
Dosinia	...	...	3	Terebratulina	...	...	4
Meroe	...	...	1	Terebratella	...	...	4
Tapes	...	...	1	Magasella	...	...	4
			—19	Thecidium	...	...	1
Family Petricolidæ.							—32
Venerupis	...	...	2	Family Rhynchonellidæ.			
				Rhynchonella	...	...	2
Family Tellinidæ.							—
Donax	...	...	2				34
Tellina	...	...	9				—
Strigilla	...	...	1				
Psammobia	...	...	2				
			—14				
Family Semelidæ.							
Semele	...	...	2				

CLASS POLYZOA.

Genera.	Species.	Genera.	Species.
Order CHILOSTOMATA.		Order CHILOSTOMATA.—Conf.	
Catenicella... ..	15	Lunulites	4
Cellaria	6	Cupularia	1
Canda	1	Selenaria	5
Caberea	3	Order CYCLOSTOMATA.	
Menipea	1	Idmonea	2
Membranipora	29	Pavotubigera	1
Micropora	5	Reticulipora	1
Steganoporella	4	Bimulticava	2
Cribrilina	7	Lichenopora	2
Mucronella	7	Entalophora	1
Microporella	16	Hornera	3
Porina	4	Retihornera	1
Lepralia	17	Supercytis... ..	1
Monoporella	5	Fasciculipora	1
Porella	4	Pustulipora	2
Smittia	12	Crisea	1
Schizoporella	23	Carbasa	1
Mastigophora	1	Tubulipora	1
Retepora	5	Discotubigera	2
Rhynchopora	1	Total Species ... 215	
Palmicellaria	1	Total Genera 41.	
Cellepora	15		
Lekythopora	1		

Class CRUSTACEA.

Gonioplax and other	..	1
Brachyureans	...	3
Squilloid	...	1
Baridia	...	1
Macrocypris...	...	1
Cythere	...	1
Paracypris	...	1
Balanus	...	2
Lepas...	...	2
Coronula	...	1

—14

Class ANNELIDA.

Serpula	...	} about 12
Vermilia	...	
Ditrypa	...	
Spirorbis	...	

Class ECHINODERMATA.

Order Echinoidea.

Family Cidaridae.

Gomocidaris...	...	2
Cidaris	...	1

Family Salenidae.

Salenia	...	1
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Family Echinidae.

Echinus	...	1
Temnechinus	...	2
Toxopneustes	...	1
Holaster	...	2
Murraechinus	...	1

Family Clypeastridae.

Fibularia	...	1
Clypeaster	...	2
Laganum	...	2
Arachnoides...	...	3

Family Cassidulidae.

Cassidulus	...	1
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Family Nucleolidae.

Echinolampas	...	1
Catopygus	...	1
Echinobrissus	...	3

Family Spatangidae.

Toxobrissus	...	1
Eupatagus	...	7
Maretia	...	1
Lovenia	...	1
Hemiaster	...	1
Micraster	...	2
Brissopsis	...	1
Brissus	...	2

Family Spatangidæ—Continued.

Linthia	1
Pericosmus... ..	3
Schizaster	1
Rhynchopygus	1
Pygorhynchus	1

Order Crinoidea.

Antedon	1
Pentacrinus	3

Order Asteroidea.

Astrogonium	1—53
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Class ZOANTHARIA.

Order Sclerodermata.

Family Turbinolidae.

Flabellum	5
Placotrochus	3
Sphenotrochus	3
Notocyathus	1
Conocyathus	1
Bistylia	1
Trematotrochus	2
Trochocyathus	2
Deltocyathus	5
Ceratotrochus	3
Microtrochus	1

Family Oculinidæ.

Amphihelia	3
Oculina	1

Family Pocilloporidæ.

Seriatopora	1
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Family Astreidæ.

Conosmilia	6
Antillia	1
Cyathosmilia	2
Cladocora	1
Plesiastrea	2
Heliastrea	1

Family Plesiopungidæ.

Thamnastrea	1
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Family Lophoseridæ.

Palæoseris	1
Bathyactis	1
Cycloseris	1

Family Eupsammidæ.

Balanophyllia	9
Dendrophyllia	2

Order Sclerobasica.

Graphularia	1
Isis	1—63

Class Spongidae.

Tethya	1
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CLASS RHIZOPODA.

Genera.	Species.	Genera.	Species.
Biloculina	6	Marginulina	1
Miliolina	20	Cristellaria	5
Spiroloculina... ..	4	Polymorphina	8
Cornuspira	3	Uvigerina	2
Articulina	2	Sagrina	1
Vertebralina... ..	1	Globigerina	3
Hauerina	1	Orbulina	1
Operculina	2	Pullenia	1
Orbitolites	1	Sphæroidina	1
Planispirina	1	Spirillina	4
Lituola	2	Discorbina	9
Reophax	2	Planorbulina	2
Placopsilina	1	Truncatulina	7
Astrorhiza	1	Anomalina	2
Textularia	9	Carpenteria	1
Verneuilina	3	Polytrema	1
Gaudryina	2	Gypsina	4
Bulimina	3	Pulvinulina	9
Bolivina	2	Rotalia	7
Cassidulina	3	Nonionina	2
Ehrenbergina	1	Polystomella	3
Lagena	6	Nummulites	1
Nodosaria	8	Amphistegina	1
Glandulina	1		
Lingulina	1	Total Species	165
Fronicularia	1		
Vaginulina	2	Total Genera 50.	

SUMMARY OF THE NUMBER OF SPECIES IN EACH CLASS.

Mammalia	...	...	9	Polyzoa	...	...	...	215
Reptilia	...	...	1	Crustacea	...	...	...	14
Pisces	...	...	12	Annelida	...	...	...	12
Cephalopoda	...	...	3	Echinodermata	...	...	...	53
Gastropoda	...	...	634	Zoantharia	...	...	...	62
Scaphopoda	...	...	9	Spongida	...	...	...	1
Petropoda	...	...	5	Rhizopoda	...	...	...	165
Lamellibranchiata	...	...	240					
Palliobranchiata	...	...	34					1519

DESCRIPTION OF THE AUTOGRAPHIC STRESS-STRAIN APPARATUS,

Used in connection with the Testing Machine at the University of Sydney, for recording the results of testing the Strength and Elasticity of Materials in Cross-breaking, Compression, and Tension,

BY PROFESSOR WARREN, M. Inst. C.E., Wh. Sc.

[With Four Plates.]

[Read before the Royal Society of N.S.W., August 1, 1888.]

THE apparatus used for drawing Stress-strain diagrams in Cross-breaking and Compression is illustrated in Plates 1 and 2, and consists of a frame R, which is rectangular in plan, and which is attached to the cross-head of the testing machine in the manner shown on Plate 2. There are two steel axes fixed to the end plates of the frame by means of lock nuts. One axis carries a brass drum 12 inches long by 5 inches in diameter; the other axis carries a pulley D, fixed upon or cast with a brass pipe E. A spiral groove is cut upon the pipe E, the pitch of which is $\frac{1}{4}$ of an inch, there is also a spiral groove cut upon the end of the drum F which is 2 inches pitch. The two spirals are connected by means of a piece of strong catgut, so that for ten revolutions of the spiral E, the drum makes one revolution. The pulley D is made to revolve by means of a steel pianoforte wire wound round its entire circumference and passing upwards over guide pulleys fixed to the ceiling and terminating in a weight of 14 pounds. The wire is led from the pulley D over a guide pulley C, fixed to the frame R and two other guide pulleys R¹ arranged so as to lead

the wire at the same level as the knife edge of the steel-yard (in order to eliminate the effect of the moment of the tension in the wire about the fulcrum of the steel-yard) and round a small drum U attached to the rider from which the poise weight is suspended by means of a bracket. The wire on the drum is wound in or payed out by means of a handle on the drum which is controled by a small friction brake. There is a strong clock spring inside the drum, so fixed that the revolution of the drum produced by winding the poise weight along the steel-yard is made to coil up the spring, and by winding the poise weight in the reverse direction the spring uncoils and brings back the drum to its original position. Thus the drum is made to revolve through an angle which is proportional to the distance through which the poise weight has been wound, and therefore proportional to the load on the specimen.

The deflection or compression as the case may be, is transmitted and recorded upon the revolving cylinder in the following manner: A steel rod H, square for a portion of its length, slides freely in bearings provided in the end plate frames, and also at the extremity of an overhanging bracket, the rod carries a slotted link in which slides a small roller which is pressed against the sides of the link by the movement of the lever N. There is also a weighted pencil which can be adjusted and fixed to any position of the square rod between the end plates of the frame. The lever N, is provided with knife edges which are pressed by the forked end of the screwed rod S, as the specimen yields. The rod S, slides or is fixed in a bearing which is attached to the test specimen in the manner shown on Plate 2.

In the compression tests the screwed rod S, is attached by means of a union screw to a steel rod which is connected at its other end with the fixed compression block of the machine. The length of the rods is arranged according to the length of the specimen tested. Both in cross-breaking and in compression the yielding of the specimen is transmitted to the knife edges of the lever N, as a simple harmonic motion which is reproduced multiplied ten times on the sliding rod H, carrying the pencil M, in the manner already referred to.

A piece of sectional paper is wrapped round the cylinder and clipped, upon which the diagram or diagrams are drawn in the following manner:—The pencil is adjusted to the datum point on the paper by means of the adjusting screw T, and the adjustable connection of the steel wire with the poise weight. The force pump is then worked until the load upon the specimen is sufficient to raise the steel-yard and the poise weight suspended from it, which causes the specimen to yield and the pencil to draw a line parallel with the axis of the drum. The pumping is continued and the poise weight wound along the steel-yard keeping it

floating in a horizontal position and balancing the load on the specimen. The length of the diagram may be increased by taking off the weights from the rod suspended from steel-yard, which is always done when small specimens are tested.

The sizes of the pulley D and the spiral grooves have been so made that the load can at once be read off on common sectional paper divided into inches and tenths.

To draw stress-strain diagrams for tension tests the frame R carrying the revolving cylinder is fixed to the underside of the cast iron longitudinal stays of the machine, and the lever N used in the cross-breaking and compression tests is removed. A second rectangular frame is attached to the upper side of the longitudinal stays before referred to, see Plate 3. Three brass plates connected with two springs of bent steel, one on each side of the centre plate, are arranged to move slightly upwards and downwards in a vertical plane between guide blocks fixed to the rectangular frame. The centre plate carries the bearings which support two levers having equal arms and which turn with very little friction upon conical centres. The end plates are attached to the rectangular frame by means of the screws W^1 and there are two screws on each side W^{11} which are used to raise or lower the lever frame and adjust it to the size of the specimen. Two steel points are fixed one to each of the levers which are pressed slightly by means of the bent spring into corresponding holes in the test piece spaced 10 inches apart. One of the levers carries two pulleys K and Q, the other an adjustable screwed rod J.

A fine steel pianoforte wire is attached to the rod J, and led over the pulleys K and Q in the manner shown, and continued over a guide pulley P the axis of which is carried by a bracket fixed to the longitudinal stays of the machine. A second axis O is also carried by this bracket upon which two pulleys of unequal size revolve together. The wire passes round the smaller pulley and terminates with a weight S. A very fine steel wire is connected to the circumference of the larger pulley and to one end of the rod H which carries the pencil, the other end of the rod H is connected to a balance weight by means of a similar wire passing over guide pulleys V^1 and V^{11} . The smaller pulley may be $\frac{1}{4}$ or $\frac{1}{2}$ the diameter of the larger, multiplying two or four times, according to the size of the diagram required.

The load is recorded on the revolving cylinder by winding the poise weight as before. The elongation produced by the load is communicated to the pencil in the following manner:—The steel points of the levers resting in the small dots or holes in the test piece move farther apart as the test piece elongates, and the pulley K moves towards the rod J and raises the weight S, the friction of the wire in the V shaped groove of the smaller pulley on the

axis O causes it to revolve, and with it the larger pulley which imparts a more or less magnified motion to the pencil.

The lever carrying the rod J does not move unless the test piece slips in the clips, in which case the arrangement of the wire over the pulleys K and Q, ensures that this movement will not be recorded as an elongation. The bent springs keep the points always in contact with the test piece. All the pulleys revolve upon conical centres.

Plate 4 shows a series of diagrams obtained from New South Wales Timbers tested as beams on supports 4 feet apart. The beams were 6 inches wide by 4 inches deep. The apparatus has been used for recording in a similar manner the results of testing rolled girders, built beams, angle and Tee-irons, bulb-irons, rails, also for recording the results in a similar manner of compression and tensile tests of iron and steel, timber, brass, bronze, &c

The apparatus was designed by J. A. McDonald, M. Inst. C.E. and the author, and made in the author's laboratory.

THE STORM OF 21ST SEPTEMBER, 1888.

BY H. C. RUSSELL, B.A., F.R.S., &c.

[One Diagram.]

[*Read before the Royal Society of N.S.W., October 3, 1888.*]

THE thunderstorm on the afternoon of Friday, 21st September, 1888, presented some features which are worthy of being placed on record. For two days before the barographs in South-Eastern Australia indicated that general uneasiness in the atmosphere which is characteristic of thunderstorm periods. That the whole system was moving eastward is shewn not only by the earlier indications in the Adelaide barogram, but also in the weather maps for those days. On Thursday rain fell at many places, and thunderstorms were reported in some places. On Friday thunderstorms occurred at many places. At Adelaide a heavy thunderstorm and sudden rise in the barometer began at 6 p.m.; at Melbourne on the same day the barometer fell 0.100 between 1 and 1.50 p.m. In New South Wales thunderstorms occurred in many places, and it was evident that the conditions giving rise to them were increasing in intensity. At Sydney at 4.30 p.m. we had the remarkable storm to which I shall refer more in detail presently, and on Saturday violent storms were general over

Victoria and New South Wales, and in many places very heavy, and it is remarkable that at Bourke and Dubbo the barograms shew a sudden rise, not the rise that is usual with thunderstorms as a precursor of a fall, but a sudden jump upwards in the curve which is carried forward. Something of the same sort appears in the Adelaide barogram for Friday.

On Friday morning the Sydney weather-chart indicated the same thundery weather which had prevailed for several days. About 1 p.m. distant thunder was first heard at the Observatory, and the storm cloud was apparently much more distant and indistinct than usual when thunder becomes audible. The morning was at Sydney very sultry, there was a good deal of cirrus about which looked like the front of the cyclone, the centre of which was then to south-east of Adelaide. About midday the clouds began to look like a distant storm, and at 3 p.m. thunder was more audible, but still faint as if at a distance; at 4 p.m. storm cloud was very marked in the south-west, and at 4.25 p.m. the distinctly cyclonic movement of the clouds was observed. The clouds could be seen circulating round the storm from north to south on the east side, and from south to north on the west side, and at the same time rising in the centre and falling suddenly outside. At 4.23 p.m. the wind which had been from east shifted suddenly to south and then south-west, by 4.30 p.m. with equal suddenness it went again south-east, and then shifted at one swing of the vane through south-west and and north round to east again, the whole interval for these changes being 25 minutes. At 4.28 the barometer began to rise suddenly, as it usually does for a thunderstorm; this continued for six minutes, during which time the total rise was 0.030in., and then suddenly that is in one minute it fell 0.044in., which is at the rate of 2.640ins. per hour. I have never before heard of a rate equal to this. Even in the most violent tropical hurricanes it is not nearly so rapid, for instance, in the one that devastated Guadalope on 6th September, 1865, the barometer fell 1.693in. in one hour. A fall of 0.100in. per hour in Europe or Australia indicates dangerous atmospheric conditions if the fall continue for any length of time, and it is only the short duration of this storm, or in other words its insignificant dimensions, that prevented such intense conditions from giving rise to most serious consequences; during just three minutes this sudden depression lasted, and then the barometer rose at the same rate which it fell. Had the instrumental record no confirmation, I should not be disposed to place implicit confidence in it, but I am obliged to believe it exactly true, because in the first place, in the record, such an error is practically impossible, and in the second because there are three other barographs at work in the building.—One,

Q—October 3, 1888.

the ordinary Richard recording aneroid, shews the same sudden change; second, one of the most perfect and largest sized Redier barographs, a kind which is acknowledged to be the most perfect instrument for recording barometer changes made in Europe, shews the same curve; and third, a new form of recording barometer which I have had made, and which is the most sensitive of the lot, also shews the same curve. In passing it may be mentioned that the Sydney barograph and the recording aneroid both shew the whole change to have amounted to 0.060, while the Redier shews only 0.040, the reason for which is no doubt that the Redier from the method of recording, was not capable of shewing the whole of such a sudden change. After this extraordinary fall and rise, the barometer fell slowly for 20 minutes as the storm passed away. Scarcely any effect was produced by the storm on the day's barometric curve, there is just the disturbance lasting half-an-hour, before and after which the diurnal curve is undisturbed. See photolithograph of this day's record attached.

At the height of this storm its aspect was very grand,—the thunder, lightning, rain, and wind, the latter sufficient to drive the rain quite horizontally over the hill, were truly grand, but all over in ten minutes, and the height of it in five minutes. Just at the moment of extreme barometric depression something, probably a thunderclap, shook the Observatory sufficiently to bring the seismoscope of the seismograph made by the Scientific Instrument Company of Cambridge into action. An electric contact was made duly recording the exact instant, and setting all the recording parts in motion. The rain fell for a few moments as shewn by the record at the rate of four inches per hour, but it is probable that this is too little, because the wind was so violent that as mentioned before the rain was driven horizontally, and did not seem to fall at all in the strongest gusts. All fell in ten minutes, and the amount was 0.56in.

We have recording barographs at Sydney, Penrith, Dubbo, Bourke, Wilcannia, Hay, Albury, and Lake George, and of course at Melbourne and Adelaide, and none of these shew any change resembling that at Sydney; and all the reports that have come in seem to indicate that the storm was quite local,—one of those small but intense cyclonic storms which occur from time to time, and after travelling for a few miles die out. When first seen from the Observatory it was south-west by west, and came steadily on from that direction, and passed to north-east on the west side of the Observatory, as shewn by the change of wind and actual observation; at Homebush and other points the hail was very heavy, but at Sydney Observatory only a few hailstones fell. they were rounded and the largest elongated, none so much as half-an-inch in length.

I have not heard of much damage, but one fact seems worth recording. From an upper window in Mr. Wiesener's workshop in George Street, a pane of glass burst outwards, as if by the sudden fall in the barometer relieving the pressure outside allowed the air inside to expand and burst the window, a phenomenon so well known in hurricane countries that they leave the door and windows open. In the recent case the momentary change of pressure represents a sudden weight almost like a blow of nearly half an ounce on each square inch of glass, which might be enough to break a large and weak pane of glass.

SOME NEW SOUTH WALES TAN-SUBSTANCES.

PART V.

(Including an account of Löwenthal's process for the estimation of tannic acid.)

By J. H. MAIDEN, F.L.S., &c., Curator of the Technological Museum, Sydney.

[Read before the Royal Society of N.S.W., October 3, 1888.]

I HAVE already intimated that the process adopted by me for all the estimations of tannin already recorded in this Society's Journal (1887) is that of Fleck. Partly because that process is of limited application, I have decided to use the process (improved) of Löwenthal, and as far as my experience extends, I believe that that process is applicable to *all* Australian vegetable products. Hallwachs (*Dingl. Polyt. Journ.*, clxxx.) has instituted comparisons between the various processes (Fleck's and Löwenthal's amongst others) for the estimation of tannin, using materials usually available to the European tanner, and the subject is so full of importance that I have already commenced a series of similar comparative analyses with Australian tanning materials, which may perhaps be advanced sufficiently for publication next year.

LÖWENTHAL'S PROCESS.

In spite of the acceptance which this process has found with European chemists, it seems strange to have to say that I know of no book which describes the process in

sufficient detail (I am speaking of a research, or an analysis as accurate as possible, and not of a merely approximate determination of tannic acid) for every purpose of the student. To my mind the process is best described by Mr. Henry R. Procter, one of the foremost of English tanning chemists, in his *Text-book of Tanning*, and also fairly well in an American publication, *The Manufacture of Leather* (C. T. Davis). But both lack a fully worked out illustration, and even Procter, while taking notice of many of the difficulties of this confessedly difficult subject, omits certain details which my own experience convinces me are worthy and necessary to be recorded.

I therefore propose to state in detail the process of Löwenthal, and I trust that this will serve the double purpose of hints for its use by Australian chemists, and also of indicating every step by which the results recorded by me in this paper have been obtained.

To show how necessary a careful and uniform system of working is required with even Löwenthal's process, considered the most perfect process yet introduced, Procter states (*Journ. Soc. Chem. Ind.* 79, 1886), "that there are certain inherent defects in the method which preclude its ever being of the highest scientific accuracy, and which require strict attention to ensure even the degree of exactness which is needed for technical purposes." Certainly I can state that the process must not be attempted unless the analyst is prepared to devote many preliminary experiments to accustom himself to it, and always to be on his guard. But with perhaps more precautions than are necessary in most methods, I have found it always to give rapid and satisfactory results.

MATERIALS EMPLOYED.

1. *Sulphindigotate of soda*. The article I have been using is of German origin, and is labelled "Indigotine 1. (Arsenfrei)." It is of the highest quality, and perfectly uniform.

2. *Potassium permanganate* (chemically pure).

3. *Hide powder*. Hide purified, and in a fine state of division, forming a kind of fluff. Nearly white, but of a creamy tint. This substance is not at present obtainable in the Colony, but when its utility shall have been realized in Australia, an enterprising firm will doubtless supply it in abundance, pure and fresh.

4. *Sulphuric acid* (chemically pure).

5. *Tannic acid* (Schering's best).

STANDARD SOLUTIONS.

A. Five grammes indigotine, together with fifty grammes sulphuric acid are agitated with one litre of distilled water, allowed to stand a night, and then filtered. The filtering is of the highest importance to secure a homogeneous liquid.

B. One gramme potassium permanganate to one litre of water.

C. One gramme tannic acid to one litre of water.

Standardisation of Indigo. 20 c.c. of Solution A (Indigo), are run from a burette of narrow calibre into three-quarters of a litre of distilled water (or the purest water obtainable), contained in a Berlin dish of about a litre capacity, that is to say, with a diameter of about $8\frac{1}{4}$ inches. The contents of the dish are rendered uniform by gentle agitation with a porcelain spoon,* which is far preferable to the glass-rod usually recommended. The solution of permanganate (B) is then run in, and care should be taken to always perform the process in precisely the same manner, as uniformity is of vital importance. The method I have found to give the most uniform results is to run in 10 c.c. of the permanganate (the liquid in the dish is agitated with the spoon after every addition for five or six seconds) to begin with, then 1 c.c. at a time until the liquid becomes of a yellowish-green. The permanganate has now to be added with the utmost caution, two or three drops at a time as the liquid becomes of a more decided yellow colour. Then one drop is added at a time, with much stirring, until the indigo is perfectly oxidised, when the liquid assumes a pure yellow colour. It is of the highest importance to note this end-reaction with precision, for unless the exact point be noted important errors will creep into the analysis. Fortunately Kathreiner has pointed out that pure yellow liquids under the above circumstances show a pinkish tinge on the circumference of the liquid. With a little practice this pink colour may be detected *immediately* it appears. Overhead light, and not too much of it, is best. 20 c.c. of indigo should require about 17 c.c. of the permanganate. I may mention, as an instance of the uniformity of results obtained by a uniform method of working, that working with two separately made batches of indigo solution, and two separately made batches of permanganate solution, the whole of nine determinations made gave 16.8 or 16.9 c.c. in each case.

METHOD OF MAKING THE DECOCTION.

Five grammes (usually) of finely divided bark, &c., are placed in a glass vessel (preferably a 40oz. beaker or flask), about half a litre of boiling water† added, and the vessel placed on the water-

* Since the above was written I have seen a paper by Mr. Procter, in the *Journ. Soc. Chem. Ind.*, 1886, in which he discards the glass-stirrer, on account of the uncertainty of the results obtained by its use, and substitutes a "disc-stirrer."

† The advantage of using boiling water is that complete exhaustion of the material takes place. Its disadvantages are that it decomposes the tannic acid slightly, though at the same time it decomposes a little of the phlobaphene which is then returned as tannic acid. It is my intention to deal separately with this subject.

bath for two or three hours, brought up to a brisk boil over a Bunsen burner, decanted on to a filter, fresh boiling water added and the process repeated until nearly a litre of water has passed through the filter. The filtrate is then made up to one litre. Uniformity in exhaustion of materials is most desirable, and some of the methods given in books lack thoroughness. The method of preparing the material for decoction has been given in former papers.

The colours of extracts (decoctions) have been determined from a litre contained in a 40oz. beaker.

THE PROCESS PROPER.

20 c.c. of indigo solution (A) are run into the Berlin dish containing $\frac{3}{4}$ litre of water, and 10 c.c. of decoction (see p. 261), are then run in and carefully stirred. [It is worthy of note that partly because the decoctions are frequently frothy, and because a comparatively small quantity is used, it is very desirable to use a delicate burette of fine calibre.]

Potassium permanganate (B) is then run in with the usual precautions to prevent overshooting of the end-reaction. The quantity required is marked, say P. (See Schedule.) A second determination, under precisely similar conditions, is marked Q. The difference between P and Q should not be more than .1 c.c. P and Q are added together, and the mean taken, which we may call R. R therefore represents the quantity of standard permanganate required to oxidise 10 c.c. of decoction + 20 c.c. of indigo.

But we already know the quantity of permanganate requisite to oxidise the indigo. Call that M. $R - M = N$ = quantity of permanganate requisite to oxidise 10 c.c. of decoction *alone*.

We now come to an important point which may be made *en parenthese*. When R is more than twice M, that is to say when the quantity of permanganate required to oxidise 10 c.c. of decoction + 20 c.c. of indigo, is more than double the quantity required to oxidise 20 c.c. of indigo alone, it has been found by experience, that the strength of the decoction has to be reduced until R is less than twice M.* This of course can readily be determined by a preliminary experiment, which is readily accomplished in practice.

* Davis (*The Manufacture of Leather*, p. 157), following Kathreiner, *Dingl. Polyt. Journ.*, cccxviii., 54, states, "The only thing of importance is that the quantity of indigo used in titration requires at least 1.5 times the quantity of potassium permanganate of that which is necessary for the oxidation of the oxidizable substances to be determined." See also Blyth, *Foods*, 333, and others who copy this statement. But I find as the result of experiment (at least with Australian barks), that if the process be conducted with the precautions I have given, it is only necessary that R should be less than twice M.

A quantity, about 100 c.c. of decoction (it is desirable to be uniform, but absolute accuracy in the quantity is unnecessary), is placed in a 10oz. beaker, about a tablespoonful of hide-powder added (it is not necessary to previously moisten, as sometimes stated), well stirred with a glass-rod, and allowed to stand about 20 hours.* At the end of this period the liquid is filtered, and is always quite transparent and usually colourless. It filters with the utmost facility. It is not even necessary to previously moisten the filter paper with distilled water, especially as the moisture thus introduced would dilute the filtrate and affect the result.

20 c.c. of indigo solution are placed in $\frac{3}{4}$ litre of water in the Berlin dish, as usual, and 10 c.c. of the above filtrate run in. Permanganate is then run in with all the precautions, and when the pure yellow colour arrives, the quantity of permanganate is noted. Call it S. Repeat, and call it T. The mean (U) is therefore the quantity of permanganate necessary to oxidise 10 c.c. of filtrate + 20 c.c. of indigo. Subtracting M (the quantity necessary to oxidise 20 c.c. of indigo) from U, we have the amount of permanganate necessary to oxidise 10 c.c. of filtrate *alone*. Call this V.

Therefore $N - V =$ obviously the quantity of permanganate necessary to oxidise the tannic acid which has been taken up by the hide powder. V represents the oxidisable impurities which hide powder is incapable of absorbing.

An actual example is given in the following form (which I have adopted as being very convenient), in which the letters M to V referred to above are used :—

STANDARDS.

(1) 20 c.c. indigo.

M.....16.9 c.c. KMnO_4 required.

(2) Gallo-tannic Acid = 9.8438.

(See separate determination below.)

20 c.c. indigo.

10 c.c. decoction (5 grms. to 1 litre).

P.....24.2 KMnO_4 required 1st test.

Q.....24.1 do. 2nd do.

R.....24.15 do. for 10 c.c. of decoction - 16.9 =
7.25.....N.

* I have proved by experiment that the hide-powder may remain in the liquid for a much longer period, without absorbing any further tannin.

Decoction steeped in hide powder.

Filter.

10 c.c. of the filtrate.

20 c.c. indigo.

S17·7 KMnO_4 required 1st test.

T17·6 do. 2nd do.

U17·65 do. for 10 c.c. filtrate - $16·9 = \cdot 75 \dots V$.

$$* 7·25 - \cdot 75 = 6·5$$

To bring it to the standard of 1 grm. to 1 litre, we have $\frac{6·5}{5} = 1·3$

$$\therefore 9·8438 : 100 :: 1·3 : x$$

$$x = \frac{130}{9·8438} = 13·206 \% \text{ tannic acid.}$$

To find *non-tannin*, substitute $\cdot 75$ for $6·5$, and we have $1·524 \% \text{ non-tannin}$.

Particulars of Substance—*Acacia salicina* (bark), Tarella, 15th August, 1887.

Decoction made 15th August, 1888 ; examined for tannin, 16th August, 1888.

We have now data on which to form results, but those results must be presented with reference to a standard. It is usually recommended to compare the amount of permanagate necessary to oxidise the tannic acid in the bark, &c., with the quantity required to oxidise the same weight of oxalic acid. But the chief objection to this is the undesirability of comparing substances so dissimilar as tannic and oxalic acids.

Procter follows von Schroeder in substituting pure tannic acid of oak-galls for oxalic acid, but, doubting that pure tannic acid is readily obtainable, inclines to recommend oxalic acid,† which is readily obtainable of uniform composition. Now Schering's tannic acid is obtainable in the Colony, and not only has it a high standard of purity, but it is fairly uniform. I have tried both oxalic acid and tannic acid ; there is no practical difficulty in the way of using the latter, and the desirability of comparing a tannic acid with a tannic acid is apparent.

* The portion of the calculation which follows will be best understood after the account of the standardisation of the permanganate, see p. 265.

† He gives reasons (*Journ. Soc. Chem. Ind.*, v., 79) for substituting gallic acid.

STANDARDISATION OF PERMANGANATE.

20 c.c. indigo.

M.....16.9 c.c. KMnO_4 required.

20 c.c. indigo.

10 c.c. decoction (1 grm. to 1 litre).

P.....25.7 KMnO_4 required 1st test.

Q.....25.8 do. 2nd do.

R.....25.75 do. for 10 c.c. decoction - 16.9 =
8.85.....N.

Decoction steeped in hide powder.

Filter.

10 c.c. of the filtrate.

20 c.c. indigo.

S17.3 KMnO_4 required 1st test.

T17.4 do. 2nd do.

U.....17.35 = do. for 10 c.c. filtrate - 16.9 =
.45.....V. $8.85 - .45 = 8.40$W.

Now the percentage of moisture in the tannic acid = 10.4 (by actual experiment).

 \therefore We have $8.4 \times 100 = 9.375$
89.6Now 9.375×1.05 (Schroeder's factor, see p. 266) = 9.8438
= our permanganate value of Schering's gallo-tannic acid.

Particulars of Substance—Schering's gallo-tannic acid; infusion made 13th August, 1888; examined for tannin 14th August, 1888.

The whole of the operations already described, in which the decoction is used, must be repeated, with substitution of Schering's tannic acid, 1 gramme to the litre of water, for the decoction.

In the example now given $N - V = 8.4$ (W) that is to say, the amount of permanganate required to oxidise the matter absorbable by hide powder.

In the sample taken the moisture was ascertained to be 10.4 per cent. ; this would bring W up to 9.375.

Now according to Schroeder (Procter, *op. cit.*, 129).....“ With the purest samples of tannin the permanganate value estimated on the total dry substance of the tannin varied by very little from that of the part of the tannin absorbed by a piece of hide, but on the average bore the proportion of 1:1.05.” Therefore, multiplying 9.375 by 1.05 we have the true permanganate value of Schering's tannic acid.

Speaking of the tannic acid taken for standardisation purposes: “ If the non-tannin does not exceed 5 per cent. of the total, it is good, but it may be used so long as the non-tannin does not exceed 10 per cent.” (Procter.)* In the present instance .45 (V) is 5.085 per cent. of 8.85 (N), and thus while slightly below the standard of “good,” comes well within the category of “may be used.”

We now are in a position to understand how results are obtained with the typical example (*Acacia salicina*).

The principal objection to the use of Löwenthal's process is that a percentage of gallic acid is absorbed by hide powder as well as the whole of the tannic acid. But inasmuch as that percentage is very small in most tan-substances, it has been the invariable practice to neglect it. What is the percentage of gallic acid in the New South Wales tan-substances I have operated upon, must be left for a separate investigation.

79. CUPANIA SEMIGLAUCA, *F. v. M.*, N.O. Sapindaceæ, B. Fl., i., 457.

Found in New South Wales and Queensland.

Sample obtained from Bangle Creek, Cambewarra. Height of tree 20 to 30 feet, diameter 8 to 12 inches. Collected 17th May, 1888. Analysed 20th to 22nd August, 1888.

Externally this bark might perhaps be mistaken by an expert for Black Wattle bark (*A. decurrens*). Certainly it would require more than a casual observation to detect its substitution if admixed with Wattle bark in the bundles as ordinarily sent to market. But on close examination the following differences

* A later statement of Procter's is in these terms,.....“ If the permanganate it consumes is less than 10 per cent. of the total consumed by the tannin, it may be taken as being one of the best of commercial preparations, and suitable for the purpose in view.” The italics are mine.

present themselves, which had best be indicated in tabular form, for they are very important from a commercial point of view :—

<i>C. semiglaucum.</i>	<i>A. decurrens.</i>
1. Slightly raspy on the outside. This appears to be distinct when once appreciated, though it might be passed over by a "horny-handed" man.	1. May be considered perfectly smooth.
2. No flutes.	2. Slight longitudinal flutes on the outside.
3. The inside bark has numerous longitudinal grooves or ridges, giving it the appearance of split hardwood. This appears to be characteristic, and brokers and others might do well to bear it in mind.	3. The inside is usually nearly as smooth as dressed timber.
4. Inside bark light brown.	4. Inside bark dark reddish-brown.

Colour of the powder, light yellowish drab.

Extract.—28.62 per cent. Colour, rich orange brown, slightly darker than that of *Callicoma serratifolia*; of moist residue, ochrey brown.

Tannic acid.—14.933 per cent. *Non-tannin and impurities*.—9.14 per cent.

80. ACACIA TETRAGONOPHYLLA, *F. v. M.*, N. O. Leguminosæ, B. Fl., ii., 330.

Found in South Australia and New South Wales.

Sample obtained from Tarella, Wilcannia. "Dead Finish." Height of tree 10 to 12 feet, diameter 6 to 8 inches. Collected 22nd August, 1887. Analysed 16th to 17th August, 1888.

One of the usual dry-country wattle barks, consisting almost entirely of bundles of fibre, even the hoary outside bark being more or less readily separable into long ribbons. The light-coloured inner bark makes excellent coarse tying material. Average thickness of bark, $\frac{1}{4}$ inch. Colour of dry powder, light brown.

Extract.—14.96 per cent. Colour, light orange-brown; of moist residue, burnt umber.

Tannic acid.—5.587 per cent. *Non-tannin and impurities*.—1.625 per cent.

81. *ACACIA SENTIS*, *F. v. M.*, N.O. Leguminosæ, B. Fl., ii., 360.
See Proc. R. S., N.S.W., xxi., 29.

Sample obtained from Cobham Lake, Milparinka. "Prickly Acacia." Height of tree, 15 to 20 feet; diameter, 4 to 6 inches. Collected 20th August, 1887. Analysed 15th to 16th August, 1888.

This bark would scarcely be taken for the product of a dry-country wattle. It is from a younger tree than the bark already described (xxi., 29), and is almost perfectly smooth and of a light brown colour. The collector reports, "When fresh it is of a beautiful bright green colour, much like the bark of *A. decurrens*. I found it easier to strip than any other bark I have stripped yet." It is very compact, and the inner bark contains some clean looking fibre. Average thickness, $\frac{1}{8}$ inch. Colour of dry powder, very light drab.

Extract—33.82 per cent. Colour, orange brown; of moist residue, light reddish-brown, inclining to Sienna brown.

Tannic acid—10.26 per cent. *Non-tannin and impurities*—1.422 per cent. A very fair percentage of tannic acid, and tending to show the advantage of stripping young trees of this species.

82. *ACACIA SALICINA*, *Lindl.*, N.O. Leguminosæ. B. Fl., ii., 367.

Found in all the Colonies except Tasmania.

Sample obtained from Tarella, Wilcannia. "Native Willow." Height of tree, 20 to 25 feet; diameter, 12 to 18 inches. Collected 15th August, 1887. Analysed 15th to 16th August, 1888.

A coarse flaky bark, not so fibrous, more compact, and altogether more promising looking than most of the dry-country barks. General colour brownish, and of inner bark reddish. From the cut ends of most, if not all of the pieces of bark, there exudes a small quantity of a resinoid gum, of a yellow colour, and pure bitter taste. This pure bitter flavour can scarcely be detected on chewing the inner layers of the bark, as it is masked by the very astringent matter present. Average thickness up to $\frac{1}{2}$ inch. Colour of dry powder, light dirty brown, with particles of dark dirty brown.

Extract.—35.28 per cent. Colour, bright ruby; of moist residue, dark pure brown.

Tannic acid—13.206 per cent. (The blacks are aware of the value of this tan-bark, as they use it for tanning wallaby and other skins.) *Non-tannin and impurities*—1.524 per cent.

83. *ACACIA SALICINA*, *Lindl.* See No. 82.

Sample obtained from Momba, Wilcannia. Height of the tree, 30 to 40 feet; diameter, 12 to 18 inches. Collected 26th August, 1887. Analysed 4th to 6th September, 1888.

Not flaky on the outside like the preceding, but a harder, "bonier" bark (if I may be allowed the expression). More rugged, but obviously a promising bark. The resinoid substance alluded to in the preceding is just noticeable. Thickness up to one inch. This species is undoubtedly worthy of conservation, and even culture, in the dry interior where it is found, particularly as the barks there are usually so poor in tannic acid. Colour of dry powder, light reddish-brown, with lighter particles.

Extract.—33.1 per cent. Colour, light ruby, inclining to orange; of moist residue, dirty brown.

Tannic acid—13.511 per cent. *Non-tannin and impurities*—1.422 per cent.

84. *ACACIA PROMINENS*, *A. Cunn.*,* N.O. Leguminosæ, B. Fl., ii, 371.

Found in New South Wales.

Sample obtained from Penshurst, Illawarra Line, near Sydney. Height of tree, 10 to 15 feet; diameter, 1½ to 2 inches. Collected 17th September, 1887. Analysed 16th to 18th August, 1888.

The percentage of moisture in this bark capable of being driven off at time of collecting, was ascertained to be 58.3 per cent.

A light coloured bark, very thin (of the thickness of stout brown paper), reminding one strongly of the well-known bark of the Sydney "Golden Wattle" (*A. longifolia*). Strips of it are very tough, and would make good tying material if not bent across too much. Colour of dry powder, reddish-brown drab.

Extract.—39.98 per cent. Colour, pale orange brown, slightly turbid on cooling, owing to the presence of mucilage, as in *A. longifolia*; of moist residue, burnt umber.

Tannic acid—14.425 per cent. *Non-tannin and impurities*—1.727 per cent.

85. *ACACIA PENDULA*, *A. Cunn.*, N.O. Leguminosæ, B. Fl., ii, 383.

Found in New South Wales and Queensland.

Sample obtained from Yandarlo, Wilcannia. "Bastard Gidgah" or "Nilyah." Height of tree, 10 to 12 feet; diameter, 4 to 6 inches. Collected 7th September, 1887. Analysed 15th and 16th August, 1888.

* Included under *A. linifolia*, Willd. in Muell. Cens., p. 45, in which I cannot concur.

A typical representative of the dry-country wattle barks. Seems to consist of nothing but flakes and layers of fibre. The inner bark is of a bright yellow, and very strong. Colour of dry powder, light yellowish-brown.

Extract.—14.52 per cent. Colour, orange-brown; of moist residue, raw umber.

Tannic acid—3.25 per cent. *Non-tannin and impurities*—1.93 per cent.

86. *ACACIA STENOPHYLLA*, *A. Cunn.*, N.O. Leguminosæ, B. Fl., ii., 385.

Found in all the Colonies except Tasmania and Western Australia.

Sample obtained from Yantara, near Milparinka. Height, 15 to 20 feet; diameter, 6 to 12 inches. Collected 22nd November, 1887. Analysed 15th to 16th September, 1888.

A rugged looking, coarsely fissured bark, prevailing colour dark grey. Possesses the characteristic appearance of the dry-country wattles. This particular bark is unusually thick, averaging $\frac{5}{8}$ inch. Colour of dry powder, light reddish-brown.

Extract—24.46 per cent. Colour, bright ruby; of moist residue, dark reddish-brown.

Tannic acid—9.448 per cent. *Non-tannin and impurities*—1.524 per cent. Obviously a wattle of some promise, considering the locality.

87. *ACACIA IMPLEXA*, *Benth.*, N.O. Leguminosæ, B. Fl., ii., 389.

From a tree cultivated at Burwood, near Sydney, and kindly sent to the author by the Rev. Dr. Woolls.

Occurs from Victoria to Queensland. Collected 15th November, 1887. Analysed 14th August, 1888.

Slightly bitter to the taste, but this sample is from an old tree, and the bitterness is less noticeable. Hoary looking, in layers and flakes. Average thickness $\frac{1}{4}$ inch. A dry looking, uninviting kind of bark. Powder very dark in colour, almost the colour of burnt umber.

Extract.—20.54 per cent. Colour, light ruby, inclining to orange; of moist residue, rather darker than that of *A. decurrens*.

Tannic acid—7.822 per cent. *Non-tannin and impurities*—1.016 per cent.

88. *ACACIA ANEURA*, *F. v. M.*, N.O. Leguminosæ, B. Fl., ii., 402.
Compare Proc. R. S., N.S.W., xxi., 32.

Sample obtained from Tarella, Wilcannia. Height, 20 to 30 feet; diameter, 6 to 12 inches. Collected 5th August, 1887. Analysed 13th to 14th August, 1888.

Another dry-country bark. The bark (xxi., 32) and the present one are much the same. The present bark is less compact, and more flaky and fibrous. The inner bark of the present sample is also lighter in colour. The dry powder exceedingly like chaff in appearance, and ranging in colour from brown to light yellow. The light particles are also exceedingly light in weight.

Extract.—12·12 per cent. Colour, light orange-brown; of moist residue, brown, like spent linseed.

Tannic acid—2·032 per cent. *Non-tannin and impurities*—·305 per cent.

89. *ACACIA ELATA*, *A. Cunn.*, N.O. Leguminosæ, B. Fl., ii., 413.

Found in New South Wales.

Sample obtained from Fitzgerald's Creek, near Springwood. Height, 50 feet; diameter, 8 inches. Collected 30th March, 1888. Analysed 13th to 14th August, 1888.

Bark flaky and somewhat rugged on the outside, but usually blackish and stained with lichens on account of its habitat (moist gullies). Prevailing colour, reddish-brown. Inner bark fibrous yet well-defined and compact. Average thickness, $\frac{3}{4}$ inch. Colour of powder, same as *A. decurrens*, but a shade lighter.

Extract.—Yields 36·2 per cent. Colour, same as *A. implexa*, but a shade darker; of moist residue, pure brown.

Tannic acid—20·11 per cent. *Non-tannin and impurities*—·914 per cent.

90. *ACACIA DECURRENS*, *Willd.* Compare Proc. R. S., N.S.W., xxi., 33 and 93.

Sample obtained from Nerriga. Height of tree, 15 to 20 feet; Diameter 8 to 12 inches. Mr. Shepherd "thinks it was stripped two months ago" (letter of 23rd March, 1888). Analysed 13th August to 14th September, 1888.

A thin smooth bark of the average kind produced by this species. Colour of dry powder, light reddish brown.

Extract.—62·54 per cent. Colour, rich ruby; of moist residue, very dark sienna-brown.

Tannic acid—36.297 per cent. *Non-tannin and impurities*—2.438 per cent. The percentage of tannic acid is extraordinary, and in order to avoid all possible error, the above is the mean of three separate analyses (not of three samples of the same liquor but of three separate liquors), which gave closely agreeing results.

Mr. Thomas Shepherd, an enterprising tanner of Cambewarra, N.S.W., has kindly furnished me with the following information in sending this sample. Of all New South Wales localities, he prefers Nerriga for *A. decurrens* bark. He says it would be quite equal to Tasmanian if it could be obtained as finely ground. From the Cambewarra bark already described (xxi., 33), Mr. Shepherd obtains only two liquors, of which the second is very weak, while from the Nerriga bark he invariably obtains three strong liquors.* In his opinion, the best time for stripping is when the trees are in bud, and have just come into flower. Next to the Nerriga bark he speaks highest of that coming from the Bega district. Nerriga is on the high table land, on the road from Nowra to Braidwood.

91. *ACACIA DECURRENS*, Willd. See 90.

Sample obtained from near Nerriga from various trees. Collected February, 1888. Analysed 14th to 15th September, 1888.

This appears to be quite a similar bark to the preceding. But when powdered they are very different in appearance, the present sample being very light in comparison, and may be styled flesh-coloured.

Extract.—53.96 per cent. Colour, light ruby; of moist residue, burnt umber.

Tannic acid—24.99 per cent. *Non-tannin and impurities*—2.032 per cent.

In regard to this second sample of *A. decurrens* bark, Mr. Shepherd informed me that not a drop of rain had fallen on it since the day it was stripped. It is sent as "an exceptionally good sample." This bark is "exceptionally good" as regards lightness of colour of extract, and consequently would produce very light-coloured leather, as also tested by me with hide powder, but it is not of the highest class in richness of tannin, as Mr. Shepherd would realize when he came to use it. The present is a good illustration of the danger of trusting to appearances with wattle bark. In Europe and America analyses of tan materials are usually made in the laboratory of the tannery itself. Mr. Shepherd states that *A. decurrens* gives a denser liquor than

* The analysis of No. 91 shows, however, that the Nerriga bark is unequal in quality.

A. binervata, sometimes so dense that he has some difficulty in making his hides sink in it. He also points out that the tannin of *A. binervata* is more quickly extracted by water than that of *A. decurrens*, and that the liquor obtained is quicker and sharper in its action than that from *A. decurrens*; he finds *A. decurrens* better adapted for heavy leather such as sole and mill-belt, but not so well for lighter work,—uppers, &c., for which he prefers *A. binervata*.

92. *ACACIA BINERVATA*, DC. Compare Proc. R. S., N.S.W., xxi., 90. See also *A. decurrens* (No. 91 this paper).

Sample from Tomerong, near Jervis Bay, between Nowra and Milton. Collected end of February, 1888. Analysed 14th to 15th September, 1888.

As received, this sample had received its first crushing in the mill. Nevertheless it was possible to pick samples showing a fair proportion of inner and outer bark. The outer bark is somewhat scaly, and the inner bark is of a light reddish-brown and very fibrous. Colour of dry powder, pale orange-brown, with much fibre. This bark cannot be mistaken for *A. decurrens*, owing to its fibrous nature.

Extract—37·8 per cent. Colour, bright ruby; of moist residue, very dark Sienna brown.

Tannic acid—19·301 per cent. *Non-tannin and impurities*—2·032 per cent.

Mr. Shepherd states that many years ago he was employed in a tan-yard in which “Ironbark” (*Eucalyptus siderophloia* or *E. leucoxylo*) was used for tan-bark. The process of tanning went on satisfactorily, but in the end the leather assumed a “bloom,” which did not take the market, although he believes the leather itself was not inferior in quality. He also remarks that working with *Eucalyptus* bark had the advantage over *Acacia* bark in that when hides were tanned too hard, part of the tannin could be removed and the hides rendered softer; *A. binervata* bark permits this to a slight degree, but not *A. decurrens*.

Although in these papers I have not touched upon the “liming process,” nor upon any of the tanning processes, the following note is interesting:—Mr. Shepherd’s experience with lime is that he can always depend upon shell-lime to obtain uniform results, whereas he cannot depend upon stone-lime, as by the use of the latter article the hides sometimes come out a dirty brown or rusty colour.

R—October 3, 1888.

93. CERATOPETALUM APETALUM, *D. Don.*, N. O. Saxifragæ, B. Fl., ii., 442.

Found in New South Wales.

Sample obtained from Fitzgerald's Creek, near Springwood "Coach-wood." Height of tree, 80 feet; diameter, 15 inches. Collected 1st April, 1888. Analysed 20th to 22nd August, 1888.

Taken from a recently fallen tree which lay across the creek, forming a natural bridge. The bark was exceedingly difficult to remove, as it did not peel in the slightest degree, and was, moreover, very tough. It is powerfully fragrant, containing abundance of coumarin. Very light grey on the outside, and nearly smooth. Inside it is of a uniform rich reddish-brown colour, and very hard and solid, harder even than the soft woods. Average thickness, $\frac{1}{2}$ inch. Colour of dry powder, hardly red enough for Sienna brown.

Extract—34.14 per cent. Colour, light ruby, with perhaps a shade of orange; of moist residue, bright reddish-brown inclining to orange-brown.

Tannic acid—20.52 per cent. *Non-tannin and impurities*—1.524 per cent.

94. CERATOPETALUM APETALUM, *D. Don.* See No. 93.

Sample obtained from Bangley Creek, Cambewarra. Height of tree, 60 to 80 feet; diameter, 1 to 3 feet. Collected 15th June, 1888. Analysed 4th to 6th September, 1888. Nos. 93 and 94 are identical in appearance. Colour of dry powder pure brown.

Extract—26.86 per cent. Colour, dark ruby; of moist residue burnt umber.

Tannic acid—13.917 per cent. *Non-tannin and impurities*—1.321 per cent.

95. BACKHOUSIA MYRTIFOLIA, *Hook et Harv.*, N. O. Myrtaceæ, B. Fl., iii., 269.

Found in New South Wales and Queensland.

Sample obtained from Fitzgerald's Creek, near Springwood. "Water Myrtle." Height of tree, 40 feet; diameter, 9 inches. Collected 30th March, 1888. Analysed 21st to 23rd August, 1888.

These trees are moss-grown, and the bark is a favourite place for orchids. Prevailing colour of outside greyish-drab, and light coloured throughout its substance. Outside slightly rugged and somewhat scaly. A compact bark, and will carry well. Average thickness $\frac{1}{2}$ inch. Colour of dry powder, drab. The fresh bark lost 36.9 per cent. in drying on water-bath.

Extract—31.44 per cent. Colour, orange-brown; of moist residue, light dirty brown.

Tannic acid—15.949 per cent. *Non-tannin and impurities*—1.32 per cent.

96. *EUGENIA SMITHII*, Poir., N.O. Myrtaceæ, B. Fl., iii., 282.

Found from Victoria to Northern Australia.

Sample obtained from Oatley's Grant, (gully leading into swamp near George's River) near Sydney. "Lilly Pilly." Height of tree, 30 feet; diameter, 9 inches. Collected 5th November, 1887. Analysed 16th to 18th August, 1888.

Full of shallow fissures. The flaky outside bark peels off with not much difficulty, exposing a thin velvety layer of friable colouring matter of the colour of red ochre. The inner bark is tough and compact, and of a darker colour. Average thickness $\frac{1}{2}$ inch. Lost 50·8 per cent. in drying on water-bath. Colour of dry powder, light reddish-brown.

Extract—33·1 per cent. Colour, rich ruby; of moist residue dark dirty brown.

Tannic acid—16·05 per cent. *Non-tannin and impurities*—1·422 per cent. Analysis of a bark of this species made under Baron Mueller's direction many years ago, gave "Tannic acid 16·9 per cent. Gallic acid 7 per cent." Compare the results obtained with the next bark.

97. *EUGENIA SMITHII*, Poir. See 96.

Sample obtained from Cambewarra, near the bank of the Shoalhaven River. Height of tree, 50 to 60 feet; diameter, $1\frac{1}{2}$ to 2 feet. Collected 5th May, 1888. Analysed 30th August to 14th September, 1888,

From a much older tree than the preceding, the general description of which will apply here. Average thickness, up to $\frac{1}{2}$ inch. As the tree grows, the flakes do not appear to enlarge considerably in thickness, but the inner solid bark does. In samples such as the present, the flaky portion is very friable. Colour of dry powder, light dirty brown.

Extract—52·88 per cent. Colour, dark ruby; of moist residue reddish-brown, near burnt umber.

Tannic acid—28·648 per cent. *Non-tannin and impurities*—2·776 per cent.

An extraordinary result (the mean of three distinct analyses), and inasmuch as the colour of the extract both alone and with hide-powder is not objectionable, this appears to be a valuable addition to the raw vegetable products of New South Wales. A tanner has undertaken to tan a sample of hide with this bark (which is by no means rare), and I will submit the leather to the Society in due course. This sample is from the bank of the river; I will endeavour to ascertain whether bark from a tree of the same size in the adjacent mountains contains a different percentage of tannic acid.

98. *HAKEA SALIGNA*, *R. Br.*, N.O. Proteaceae, B. Fl., v., 512.

Found in New South Wales and Queensland.

Sample obtained from The Valley, near Springwood. Height of the tree, 30 feet; diameter, 7 inches. Collected 31st March, 1888. Analysed 20th to 22nd August, 1888.

A tolerably smooth bark, with a few small rounded excrescences and many lichens outside. Colour grey. The inner surface has the characteristic lenticular appearance of Proteaceous barks. A clean-looking, solid bark of comparatively light colour throughout. Thickness $\frac{1}{2}$ inch. Loses moisture to the extent of 47.4 per cent. on the water bath. Colour of dry powder, warm light brown.

Extract—36.96 per cent. Colour, light ruby, with perhaps a shade of orange; of moist residue, ochrey-brown.

Tannic acid—20.42 per cent. *Non-tannin and impurities*—1.32 per cent.

99. *CASUARINA SUBEROSA*, *Otto et Dietr.*, N.O. Casuarineae, B. Fl., vi., 197.

Found in Tasmania, Victoria to Queensland.

Sample obtained from Bangley Creek, Cambewarra. "Forest Oak." Height of tree, 15 to 20 feet; diameter, 8 inches. Collected 19th April, 1888. Analysed 21st to 23rd August, 1888.

A rugged looking bark, with hard corky layers. Total thickness 1 inch. Inner bark reddish-brown, and displaying the lenticular appearance on its inner surface characteristic of the genus. Colour of powder, ochrey-brown.

Extract—24.6 per cent. Colour rich orange-brown; of moist residue, Vandyke brown.

Tannic acid—13.511 per cent. *Non-tannin and impurities*—1.32 per cent.

100. *CASUARINA TORULOSA*, *Ait.*, N.O. Casuarineae, B. Fl., vi., 200.

Found in New South Wales and Queensland.

Sample obtained from The Valley, near Springwood. "Drooping She-Oak." Height of tree, 30 feet; diameter, 15 inches. Collected 13th April, 1888. Analysed 23rd to 25th August, 1888.

The appearance of this bark is characteristic. The furrowing is deep, and is divided transversely. In flaky barks the flakes are of course attached by their flat sides to the tree, but in this instance, each flake (roughly about an inch by one and a half inch and a quarter of an inch thick) is set on end with great regularity, and each may be detached without removing its neighbour. Each flake is corky. Inner bark very coarsely lenticular. Average thickness of inner bark $\frac{1}{2}$ inch, of outer bark (flakes) 1 inch. Colour of dry powder ochrey-brown.

Extract—10·78 per cent. Colour light orange-brown; of moist residue Vandyke brown.

Tannic acid—5·384 per cent. *Non-tannin and impurities*—1·016 per cent., (determined on fair sections of inner and outer bark, as usual). The flakes of the outer bark are so readily separable that the author considered it useful to make separate determinations of the inner and outer barks. *Outer bark*—Yields extract to water 3·08 per cent. Colour of dry powder, ground coffee, which it much resembles; colour of extract, sherry; of moist residue, Vandyke brown. Tannic acid 1·524 per cent. *Non-tannin and impurities*, ·609 per cent. *Inner bark*—Extract to water 31·38 per cent. Colour of dry powder reddish-buff; of extract, orange-brown inclining to light ruby; of moist residue, raw sienna inclining to brown. Tannic acid, 12·495 per cent. *Non-tannin and impurities*, 1·117 per cent. From this it will be seen that the inner bark is rich in tannic acid. These trees are only used for fuel, for which they are excellent, and it does seem a waste to allow so much tan-material to go unused.

APP'S INDUCTION COIL.

In the Anniversary address delivered by the late Prof. Smith, and published in the Journal of the Royal Society of N.S.W., Vol. xviii., 1884, on page 14, line 13 it is stated—"This powerful machine was ruined (as I understood) at the Paris Exhibition." Mr. Apps in a note, which Prof C. Piazza Smyth has communicated to the Honorary Secretaries under the date 11th August, 1888, says:—"I am sorry you have been misinformed from Australia about Mr. Spottiswoode's (45" spark) coil. I employed an Assistant at the Exhibition (in Paris) and he unscrewed one of the connecting rods leading to the primary wire and thereby stopped the primary current and no other damage was done. I returned the coil afterwards to Mr. Spottiswoode, exhibiting the full length of spark to him to show that the coil was uninjured."

WEDNESDAY, OCTOBER 3, 1888.

SIR ALFRED ROBERTS, President, in the Chair.

The minutes of the last meeting were read and confirmed.

The certificates of two candidates were read for the third time, of three for the second time, and of five for the first time.

The ballot for the election of the candidates whose certificates had been read for the third time, was postponed to the next General Meeting in consequence of a quorum not being present.

In the absence of the author, Mr. F. B. Kyngdon read extracts from a paper by Baron Ferd. von Mueller, K.C.M.G., F.R.S., &c., on "Considerations of Phytographic Expressions and Arrangements."

Some remarks were made by Mr. W. A. Dixon, F.C.S.

Prof. Liversidge, in the absence of the author, read extracts from a paper by Prof. Ralph Tate, F.G.S., F.L.S., "Census of the Fauna of the Older Tertiary of Australia."

Mr. H. C. Russell, B.A., F.R.S., read a paper "Notes on the Storm of 21st September, 1888."

The reading of the paper caused a discussion, in the course of which several of those present related their experience of similar storms in the interior, which by their violence caused great damage.

Mr. Russell remarked that he had omitted to point out that although such cyclonic disturbances seldom visited the coast, experience had proved that they were not unknown, and another such storm of greater dimensions would probably cause considerable havoc in the city if the unstable class of buildings so much in vogue were adhered to.

A hearty vote of thanks was tendered to Mr. Russell for his paper, and the President remarked that such interesting and practical contributions were of great value to the Society.

Mr. J. H. Maiden read some extracts from Part V. of his series on "Some New South Wales Tan Substances." He also exhibited a number of indigenous barks by way of illustration, and gave the proportions of tannic acid contained in each case. Mr. Maiden sees a great future before the industry in tan substances in this Colony, and his remarks were listened to with evident pleasure.

The following donations received during the months of August and September were laid upon the table and acknowledged:—

DONATIONS RECEIVED DURING THE MONTHS OF AUGUST AND SEPTEMBER, 1888.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

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RESULTS OF OBSERVATIONS OF COMETS I. AND II,
1888, AT WINDSOR, N.S.W.

BY JOHN TEBBUTT, F.R.A.S., &c.

[Read before the Royal Society of N.S.W., November 7, 1888.]

COMET I., 1888.

THIS comet was detected with the naked eye by Mr. Sawerthal of the photographic department of the Royal Observatory, Cape of Good Hope, on the morning of February 19th, civil time, 1888. A position was at once determined by Mr. Finlay, first assistant at the Observatory, and telegraphed to Kiel, whence information of the discovery was distributed to all parts of the astronomical world. About noon on February 23rd, I learned from the *Sydney Morning Herald*, that the comet had been discovered. Its rough position for the morning of discovery was given, but the name of the discoverer did not become known to me for some weeks. It appeared from the telegraphic announcement in the *Herald* that reports of the comet's appearance had been received from various parts of Victoria, the first being from a Mr. Nolan at Bransholme where the comet was seen in the night of the 19th, meaning, I presume, the morning of the 20th. On the morning of the 23rd it was seen by Mr. Hunter, Chief Officer of the Julia Percy, and was described as having a tail about three degrees long. Unfortunately when intelligence of the discovery reached me, the weather was becoming unfavourable for observation, and it was not till the morning of the 28th, civil time, that I succeeded in securing a position. Seventeen excellent measures were then obtained with the position filar-micrometer of the 8 inch equatorial. The nucleus during the first three weeks was stellar, and, except when blurred by atmospheric causes, was well adapted for accurate observation. On the morning of March 29th I found that the comet's nucleus had become considerably elongated, and presented two points of condensation. A brilliant point in the *following* condensation was chosen for observation. On the following morning it was remarked that the nucleus had become greatly elongated, its major axis making an angle of about 20° or 30° with a parallel of declination. On and after the this date the *following* or brighter part of the nucleus was observed, but in consequence of the major axis being approximately in the direction of a parallel of declination the resulting differences of right ascension are not so satisfactory as the differences of declination. The nucleus was

very distinctly seen in strong twilight with the 8 inch telescope and a magnifying power of 74 diameters, and comparisons could therefore be made on these occasions without artificial illumination of the micrometer-threads. The comparisons were continued until the comet was extinguished in the increasing twilight.

The following table containing the approximate sidereal times of the comet's last comparison-transit and of sunrise on each morning at the close of the series will convey some impression of the brightness of the comet in twilight:—

Astronomical Date.	Sidereal Time of		Interval.
	Last Comparison.	Sunrise.	
	h. m.	h. m.	m.
March 19	17 33	17 56	23
„ 21	17 37	18 5	28
„ 25	18 5	18 24	19
„ 28	18 13	18 38	25
„ 29	18 20	18 42	22
„ 31	18 28	18 52	24
April 1	18 33	18 57	24
„ 2	18 33	19 2	29

There was very thin cloud on March 19th and 29th. The Windsor positions extend from February 28th to April 3rd. After the last mentioned date clouds or fog prevented observation for several mornings until the comet at length got too far north to be followed. All the positions depend on a filar-micrometer with a single position and two distance-threads. The micrometer was so adjusted that the position-thread was coincident with a meridian of right ascension and the distance-threads were parallel to the equator. In each comparison, therefore, a single transit was observed for difference of right ascension. The instrumental differences are all corrected for refraction, which correction amounts in no case to a second of arc. The earlier observations of March 7th and 14th were made with the 4½ inch, and all the other observations with the 8 inch-equatorial. One authority only, and that a good one, has been selected for the mean place of each comparison-star. The usual reductions from the mean to the apparent places, and likewise the logarithmic factors for the reduction of the comet's observed places to the centre of the earth are added. P denotes the comet's equatorial horizontal parallax in seconds of arc, and p and q the reductions in seconds of time and arc respectively. The observations fully reduced have long since been forwarded to Europe in three instalments. The first instalment, which was published in the *Astronomische Nachrichten* of April 16th, turned out exceedingly useful for a provisional determination of the elliptic elements of the comet's orbit by Herr A. Berberich, of the Recheninstitut, Berlin. The position

telegraphed from the Cape of Good Hope on the date of discovery was unfortunately affected with some error, which rendered it useless as a basis for calculation. The Windsor position for February 27th, resting as it did on seventeen excellent comparisons with well-determined stars, was adopted by Herr Berberich in conjunction with observations at Palermo on March 13th, Rome on March 24th, Kiel on April 5th, and Kiel and Hamburg on April 12th. The comet did not become visible to the Southern Observatories of Europe till about the 13th March. The following are the elliptic elements arrived at by Herr Berberich:—

$T = 1888$, March 17, 03844, Berlin M. Time.

$$\left. \begin{array}{l} \omega = 359 \quad 55 \quad 20.3 \\ \Omega = 245 \quad 23 \quad 25.8 \\ i = 42 \quad 15 \quad 19.8 \end{array} \right\} \text{Mean Equinox, 1888-0.}$$

Log. $e = 9.998290$.
Log. $q = 9.844346$.

These elements represent the first and last positions exactly and the three intermediate ones very closely. The time of revolution is estimated at about 2370 years, but it does not appear that the comet was observed at its previous return to perihelion. The elements above given are a very close approximation to the true orbit inasmuch as Dr. B. von Engelhardt observed the comet at his private observatory, Dresden, so late as July 15th when the correction to the ephemeris was found to be only +2.16 s. in right ascension, and —14.6" in declination. The comet was at no time a very conspicuous object to the unassisted eye and its maximum length of tail was only about three degrees.

COMET II., 1888.

This is a return of the well-known comet of Encke. This object was originally discovered by Mechain at Paris, on January 17th 1786. It was not again seen till the return of 1795, when Miss Caroline Herschel, sister of the celebrated Sir William Herschel, detected it on November 7th of that year. At the return of 1805 the comet was again found by Thulis at Marseilles on October 19th, but no suspicion appears to have been entertained that these three appearances were of one and the same body. From the observations in 1805 Encke computed an elliptic orbit with a period of about twelve years. On November 26th 1818, the well-known Pons of Marseilles discovered a small comet which was observed for nearly seven weeks. These observations served as a better foundation for the determination of elliptic elements, and Encke found that they gave a period of about $3\frac{1}{2}$ years. He also showed that the perihelion distance and the position-elements of the orbit agreed closely with those of the Comets of 1786, 1795 and 1805. Between 1786 and 1818 the comet had therefore passed through perihelion

seven times without detection. Encke after allowing for planetary perturbation predicted that the comet would again pass through perihelion on May 24th 1822, and an ephemeris was prepared in order to enable astronomers to rediscover it at this return. On laying down its theoretical track in the heavens, it was found that the comet could not possibly appear above the horizon of European Observatories. An ephemeris was therefore dispatched to the private observatory of Sir Thomas Brisbane at Parramatta in our colony, which, I believe, was the only southern observatory then in existence. Nine days after the perihelion passage, or on June 2nd, the comet was detected at Parramatta by Rümker, afterwards the director of the Hamburg Observatory, and with the imperfect instrumental means at his command he succeeded in following it for a period of three weeks. These observations were the only data obtained at this appearance, and in the hands of Encke they served for a correction of the orbit and a more accurate prediction of the comet's appearance in 1825. The investigation of the comet's movements thus crowned with such marked success resulted in the name of Encke being permanently attached to the comet. The subsequent returns of this interesting object have been calculated and verified by observation on every occasion, the last being the twentieth, since 1822. Five returns have been witnessed at Windsor, namely in 1862, 1865, 1875, 1878, and 1888. In 1878 the first view of the comet was obtained at the same place, but only about nine hours previously to the first observation at the Royal Observatory, Cape of Good Hope. Since the death of Encke the theory of the comet's movements were the special study of Dr. von Asten of Pulkowa. On the premature death of the latter astronomer, the comet came under the care of Dr. O. Backlund of St. Petersburg. Through the courtesy of Drs. Backlund and Seraphimoff, I was supplied with an ephemeris for the recent return, and I accordingly commenced a search as soon as there appeared to be a probability of detecting it in the evening twilight. My first attempt was on the evening of July 6th, but it failed. Other avocations prevented a search on the following evening, but on July 8th at 6 h. 10 m. p.m. the comet was found almost exactly in the place assigned to it in the ephemeris. The only other notice which I have yet seen of the discovery is a telegram from the Cape of Good Hope in the *Astronomische Nachrichten*, announcing the first observation on August 3rd, or 26 days later than that made at Windsor. When first detected at Windsor the comet appeared in the $4\frac{1}{2}$ inch equatorial as a round nebulous star uniformly condensed, about 1' in diameter, and without coma or tail. Doubtless the evening twilight had much to do with the non-appearance of the usual coma. From July 8th to 18th the comet was shut out from observation with the 8 inch equatorial

by a portion of the observatory buildings, and the positions had to be determined with the small instrument. The moon too, increased nightly in brilliancy and the comet became quite invisible. On the withdrawal of the full moon the comet was picked up again with the 8 inch telescope and observed till August 1st, when, owing to its increasing distance from the sun and earth it was little more than a faint whiteness about 2' in diameter on the blue of the heavens. All the observations in this paper were made with a square bar-micrometer adapted to both equatorials. There being no definite point for observation, all that could be done was to observe the bisection of the nebulous mass at the edges of the micrometer-bars. In the reduction of the comparisons corrections were carefully applied for small errors in the form of the micrometer.

COMET I., (SAWERTHAL) 1888.

Date.	Windsor Mean Time.	Comet-Star.		Compa.	Comet's Apparent.		Log. Parallax Factors.		Reductions to App. Place.		Comp. Stat.
		$\Delta \alpha$	$\Delta \delta$		α	δ	$\frac{P}{P}$	$\frac{q}{P}$	α	δ	
1888.	h. m. s.	m. s.			h. m. s.	" "					
Feb. 27	16 35 34	+ 0 33.93		17	20 2 10.75		-8.8746		-8.00		1
" 27	16 35 34	- 0 5.13	- 7 21.6	17	20 2 10.93	-44 20 28.2	-8.8746	-9.3789	-2.01	+6.0	2
" 28	16 34 30	+ 2 13.81	+ 13 52.0	4	20 6 53.64	-42 52 39.8	-8.8651	-9.4104	-1.95	+5.7	3
Mar. 2	16 26 47	- 0 46.42	- 2 5.1	9	20 20 1.47	-38 24 19.1	-8.8401	-9.5023	-1.81	+4.0	4
" 2	17 9 9	- 7 22.11	+ 6 46.6	3	20 20 13.75	-38 21 26.3	-8.8138	-9.3576	-1.65	+5.6	5
" 3	16 42 37	+ 15 13.61	- 4 32.6	5	20 24 18.09	-36 52 7.3	-8.8234	-9.4740	-1.69	+4.5	6
" 3	16 42 37	+ 9 53.77	+ 5 31.4	5	20 24 17.93	-36 52 6.9	-8.8234	-9.4740	-1.72	+4.2	7
" 4	16 35 54	+ 11 46.48	+ 8 5.3	5	20 28 18.57	-35 21 6.2	-8.8187	-9.5123	-1.67	+3.8	8
" 6	17 8 19	- 0 56.62	+ 4 33.3	13	20 36 9.65	-32 15 14.2	-8.7818	-9.4653	-1.65	+2.2	9
" 7	15 22 27	+ 1 7.90	+ 3 5.5	7	20 39 38.31	-30 49 50.3	-8.8103	-9.6974	-1.60	+1.9	10
" 7	16 43 48	+ 1 20.73	+ 8 16.4	21	20 39 51.14	-30 44 39.4	-8.7915	-9.5430	-1.60	+1.9	11
" 8	16 49 29	- 0 11.15	+ 2 15.4	18	20 43 32.88	-29 13 14.6	-8.7812	-9.5468	-1.57	+1.4	12
" 9	16 46 4	+ 3 48.90		9	20 47 9.81		-8.7768		-1.52		13
" 9	16 46 4	+ 2 19.53	- 0 46.1	9	20 47 9.57	-27 40 26.7	-8.7768	-9.5888	-1.52	+1.0	14
" 9	16 46 4	+ 0 51.06		9	20 47 9.51		-8.7768		-1.53		15
" 10	16 58 56	+ 8 8.05	+ 3 42.3	5	20 50 45.18	-28 7 54.9	-8.7621	-9.5800	-1.46	+0.9	16
" 11	17 14 58	+ 6 52.63	+ 6 36.3	5	20 54 17.59	-24 35 33.8	-8.7434	-9.5487	-1.44	+0.4	17
" 11	17 14 58	+ 5 34.69		5	20 54 17.90		-8.7434		-1.44		18
" 11	17 14 58	+ 3 49.73		5	20 54 17.54		-8.7434		-1.45		19
" 14	16 21 0	+ 6 26.13	+ 9 44.0	5	21 4 26.58	-20 8 6.9	-8.7628	-9.6804	-1.35	+0.8	20
" 14	17 19 46	+ 6 34.09	+ 13 21.2	5	21 4 34.54	-20 4 29.7	-8.7234	-9.5896	-1.35	+0.8	21
" 15	17 19 18	- 3 43.17	- 8 28.2	8	21 7 55.86	-18 35 43.4	-8.7194	-9.6047	-1.36	+1.7	22
" 17	17 13 51	+ 5 1.16	- 2 56.4	9	21 14 32.66	-15 41 9.6	-8.7164	-9.6361	-1.28	-0.1	23
" 17	17 13 51	- 0 44.61		9	21 14 33.10		-8.7164		-1.30		24
" 18	17 16 50	+ 0 88.15		9	21 17 50.15		-8.7101		-1.27		25
" 18	17 16 50	- 3 24.47	-10 38.8	9	21 17 49.98	-14 15 4.3	-8.7101	-9.6447	-1.28	-2.9	26
" 19	17 31 54	+ 0 49.03	-14 59.1	9	21 21 7.85	-12 49 19.3	-8.6913	-9.6464	-1.24	-3.1	27
" 21	16 57 11	+ 0 2.45	+ 4 0.8	5	21 27 31.69	-10 5 23.5	-8.7184	-9.6874	-1.21	-3.7	28
" 21	16 57 3	+ 2 1.73	+ 10 20.4	6	21 27 35.84	-10 3 40.6	-8.7090	-9.6721	-1.20	-3.7	29
" 25	17 35 58	- 0 8.27	- 8 49.1	13	21 40 22.62	- 4 47 33.8	-8.6721	-9.7084	-1.13	-5.1	30
" 28	17 31 52	+ 5 30.67	+ 1 42.9	4	21 49 49.05	- 1 5 59.7	-8.6593	-9.7333	-1.06	-5.6	31
" 29	17 34 32	+ 0 48.44	+ 1 8.5	6	21 52 56.55	+ 0 5 4.0	-8.6683	-9.7412	-1.06	-6.2	32
" 29	17 34 32	- 2 23.55	+ 1 4.6	6	21 52 56.48	+ 0 4 59.5	-8.6683	-9.7412	-1.07	-6.2	33
" 31	17 38 38	- 4 17.68	+ 11 27.3	5	21 59 9.23	+ 2 23 30.4	-8.6614	-9.7555	-1.05	-6.5	34
April 1	17 38 25	- 0 57.91	-12 21.3	7	22 2 14.25	+ 3 28 53.1	-8.6610	-9.7621	-1.02	-7.0	35
" 1	17 38 25	- 2 5.42		7	22 2 13.85		-8.6610		-1.03		36
" 2	17 40 30	+ 5 17.64	+ 3 19.1	3	22 5 18.45	+ 4 33 51.3	-8.6577	-9.7687	-0.99	-7.1	37
" 2	17 40 30	+ 4 24.08		3	22 5 18.11		-8.6577		-0.99		38

Mean Places of the Comparison-Stars for 1888-0.

Star.	α			δ	Authority.
	h.	m.	s.	° ' "	
1	20	1	38.83	-44 14 28.6	Stone, 10799.
2	20	2	18.07	-44 13 12.6	Stone, 10803.
3	20	4	41.78	-43 6 30.5	Stone, 10820.
4	20	20	49.7	-38 23 19	Anonymous, = 8 mag. Approx. Position.
5	20	27	37.71	-38 28 18.5	Stone, 10865.
6	20	9	6.17	-36 47 39.2	Stone, 10840.
7	20	14	25.88	-36 57 42.9	Cordoba Zone 22.55.
8	20	16	33.76	-35 29 15.3	Stone, 10897.
9	20	37	7.92	-32 19 49.7	Stone, 11038.
10	20	38	32.01	-30 52 57.7	Stone, 11047.
11	20	43	45.60	-29 14 31.4	Wash. Mural Cir. Zone, 132.73.
12	20	43	23.43	-27 46 53.3	Stone, 11075.
13	20	44	51.56	-27 39 41.6	Stone, 11088.
14	20	46	19.96	-27 35 16.9	Cordoba Zone, 40.104.
15	20	42	38.50	-26 11 38.1	Stone, 11072.
16	20	47	26.40	-24 42 10.5	Stone, 11116.
17	20	48	44.65	-24 39 33.9	Cordoba Zone, 32.36.
18	20	50	29.28	-24 37 25.9	Arg.-Oeltzen, 20673.
19	20	58	1.80	-20 17 50.1	Stone, 11187.
20	21	11	40.39	-18 27 13.5	Greenw. 7 Yr. Cat. 1864, 2411.
21	21	9	32.78	-15 38 11.1	Stone, 11276.
22	21	15	19.01	-15 37 48.1	Arg.-Oeltzen 21323.
23	21	17	13.27	-13 59 31.7	Lamont (5), 3612.
24	21	21	15.73	-14 4 22.6	Schjellerup, 8679-80.
25	21	20	30.08	-12 34 17.1	Lamont (5), 3639.
26	21	27	35.35	-10 9 20.6	Lamont (5), 3678.
27	21	25	35.31	-10 13 57.3	Lamont (5), 3668.
28	21	40	32.02	-4 38 39.6	Lamont (3), 4381.
29	21	44	29.44	-1 7 36.8	Glasgow Cat. 1870, 5594.
30	21	52	9.17	+ 0 4 1.7	Glasgow Cat. 1870, 5639.
31	21	55	21.10	+ 0 4 1.1	Glasgow Cat. 1870, 5660.
32	22	3	27.96	+ 2 11 9.9	Glasgow Cat. 1870, 5705.
33	22	3	13.18	+ 3 41 20.4	Glasgow Cat. 1870, 5703.
34	22	4	20.30	+ 3 33 10.1	Lalande, 43221.
35	22	0	1.80	+ 4 30 39.3	Glasgow Cat. 1870, 5683.
36	22	0	55.08	+ 4 38 58.9	Schjellerup, 9018.

COMET II., (ENCKE) 1888.

Date.	Windsor Mean Time.	Comet—Star.			Cumps	Comet's Apparent.		Log. Parallax Factors.		Reductions to App. Place.		Comp. Star.
		$\Delta \alpha$	$\Delta \delta$	" "		α	δ	$\frac{p}{P}$	$\frac{q}{P}$	α	δ	
1888.	h. m. s.	m. s.	" "	" "	h. m. s.	° ' "				s.	" "	
July 8	6 33 29	+5 25.35	-8 8.1	3	8 47 54.93	+12 40 24.1	+8.7368	-0.7711	-0.53	-2.8	1	
" 9	6 33 29	+5 20.14	-11 3.3	3	8 47 55.48	+12 40 27.4	+8.7368	-0.7711	-0.53	-2.8	2	
" 10	6 34 31	+5 10.78	-1 49.2	4	9 2 9.43	+10 44 13.9	+8.7303	-0.7705	-0.45	-3.7	3	
" 11	6 29 30	-2 27.83	-4 24.0	5	9 9 13.13	+9 45 41.3	+8.7235	-0.7718	-0.44	-3.7	4	
" 15	6 43 58	+5 15.33	+14 40.1	5	9 37 51.98	+5 23 58.0	+8.7203	-0.7504	-0.36	-3.0	5	
" 15	6 43 58	+1 41.41	-4 55.5	5	9 37 50.30	+5 24 8.7	+8.7203	-0.7504	-0.35	-2.9	6	
" 16	6 45 25	-3 51.89	-17 14.0	5	9 45 4.92	+4 15 50.3	+8.7183	-0.7563	-0.31	-2.9	7	
" 16	6 45 25	-5 31.61	-3 0.1	5	9 45 5.29	+4 15 53.0	+8.7183	-0.7563	-0.30	-2.9	8	
" 18	6 46 59	+2 48.46	-5 8.7	4	9 59 49.62	+1 56 29.9	+8.7135	-0.7485	-0.28	-3.2	9	
" 18	6 46 59	-4 31.87	-6 19.3	4	9 59 49.25	+1 56 20.7	+8.7135	-0.7485	-0.25	-3.1	10	
" 25	6 52 16	+1 17.98	-6 19.3	8	10 54 8.30	-6 33 54.4	+8.6678	-0.7021	-0.06	-4.1	11	
" 26	6 53 6	+4 48.39	-0 8.3	6	11 2 15.76	-7 47 25.9	+8.6656	-0.6926	-0.06	-4.3	12	
" 31	7 11 29	+1 57.72	-2 50.8	14	11 44 5.67	-13 46 8.5	+8.7005	-0.6426	+0.13	-5.1	13	
Aug. 1	7 0 27	+1 59.16	-0 45.0	9	11 53 35.32	-14 53 50.3	+8.6851	-0.6183	+0.16	-5.3	14	
" 1	7 0 27	+1 4.05	-3 13.1	9	11 53 35.21	-14 53 18.4	+8.6851	-0.6183	+0.16	-5.3	15	

8—November 7, 1888.

Mean Places of the Comparison Stars for 1888.0.

Star.	α			δ			Authorities.
	h.	m.	s.	°	'	"	
1	8	42	30.10	+12	57	35.0	Lalande, 17336; Glasgow Cat. 1870, 2247.
2	8	42	35.87	+13	0	33.5	Lalande, 17339.
3	9	7	20.67	+10	44	5.8	Lalande, 18179; Glasgow Cat. 1870, 2377.
4	9	11	41.40	+9	50	8.0	Star = 9 mag. Approximate Position.
5	9	32	37.01	+5	9	18.9	Lalande, 18940; Greenw. Cat. 1850, 680; Glasgow Cat. 1870, 2501; Bruxelles Obs. 1873, 1517; Cape Obs. 1881, 285.
6	9	36	9.24	+5	29	7.1	Lalande, 19045.
7	9	48	57.12	+4	33	7.1	Lalande, 18398.
8	9	50	37.20	+4	18	55.0	Star = 9 mag. Approximate Position.
9	9	57	7.44	+2	1	34.8	Lalande, 18622; Lamont (1), 2779.
10	10	4	21.47	+1	59	53.1	Lamont (1), 2834.
11	10	52	50.70	-6	27	31.0	Star = 9 mag. Approximate Position.
12	10	57	22.43	-7	47	13.3	Lalande, 21186; Lamont (3), 1017; Schjellerup, 4022.
13	11	42	59.82	-13	43	12.6	Radcliffe Obs. 1881, 266.
14	11	50	37.00	-14	53	0.0	Star = 8½ mag. Approximate Position.
15	11	51	31.00	-14	50	0.0	Star = 8½ mag. Approximate Position.

THE DESERT SANDSTONE.

BY THE REV. J. E. TENISON-WOODS, F.G.S., F.L.S., &c.

[With Plates.]

[Read before the Royal Society of N.S.W., November 7, 1883.]

ALL round the Australian coast, proceeding northwards, say from the latitude of Brisbane there occurs at intervals, and in patches of different sizes, a peculiar formation which goes by the name of Desert Sandstone. It varies much in colour and in character, though mostly a bright or a livid red, yet it is often white, yellow, and of various intermediate shades, or mottled. Usually it is composed of sand consisting of small grains more or less firmly cemented together. There is generally a somewhat rounded appearance in the grains, though they are not abraded in the characteristic manner of eolian sands. Yet it is not entirely composed of sand; in North Australia 50 feet and more of the upper surface is magnesite or carbonate of magnesia, and there are other admixtures in places, though usually the rock is composed of spherical grains of sand cemented together or hardened into quartzite. There are certain constant features in the formation which entitle it to the name of Desert Sandstone, namely:—(1) It usually gives rise to a desert country of a very profitless character, with a scanty vegetation, yet not wholly destitute of fair sized trees and poor grasses. (2) It is utterly destitute of fossils, unless in certain cases impressions of leaves, seed-vessels, and fragments of

silicified wood. An exception to this is mentioned by Mr. Taylor. I may state, however, that I searched in vain in the neighbourhood of the locality named, and my impressions are that it would be more likely that the fossils belonged to the underlying Cretaceous formation. (3) It is of a broken precipitous character, forming tablelands with precipitous faces, and round, flat-topped hills. (4) Wherever met with it bears marks of being much denuded. Water seems easily to have broken it up and denuded it, cutting it down into astounding precipices and forming country of the roughest description, utterly impassable for man or beast. (5) Its generally uniform height is another feature; 500 to 600 feet is the highest elevation in North Australia, but in North-Western Australia Mr. Frank Gregory speaks of the same formation attaining 1000 feet high. The Desert Sandstone is found in detached hills and plateaux of varying extent. (6) In close proximity to it there are nearly always recent volcanic formations.

So peculiar a formation was very early a puzzling geological problem to those who made a study of the geology and physical geography of Australia. Mr. Daintree imagined that, at one time, the strata to which he was the first to give the name of "Desert Sandstone," extended over the whole Continent, and his opinion has been more or less followed by subsequent geologists and explorers in their writings and maps. It is certain that the formation reappears very often on the coast and throughout the interior in the form of detached outliers with a certain uniform aspect, so that it may be easily believed that such outliers were once connected together. My own observations have made me notice further that these outliers of Desert Sandstone are always in the neighbourhood of rivers and creeks, and seem equally connected with the ancient volcanic emanations which form portions of the dividing ranges. The following is Mr. Daintree's description:—

"On the eastern branches of the upper Flinders River and elsewhere fine sections are exposed of lava, resting on horizontal beds of coarse grit and conglomerate, which lie in turn unconformably on olive-coloured and grey shales with interstratified bands and nodules of argillaceous limestone, containing fossils of cretaceous affinities. I have called this upper conglomerate series "Desert Sandstone," from the sandy barren character of its disintegrated soil, which makes the term particularly applicable. Only a few rolled fragments of coniferous wood have been found imbedded in it, proving nothing as to its

* Daintree, "Notes on the Geology of the Colony of Queensland, with an appendix containing descriptions of the fossils," from the "Quarterly Journal of the Geological Society" for August, 1872, p. 275.

age ; and all that can be asserted is that its horizon is above and unconformable to the Cretaceous series of the Flinders.

"Without doubt it is the most recent, widely spread stratified deposit developed in Queensland. The denudation of the Desert Sandstone since it became dry land has been excessive ; but as will be seen by the geological map (pl. ix.), there still remains a large tract *in situ*, whilst outliers and isolated ridges are to be met with in the most unexpected localities. A view of a cliff section of Desert Sandstone with outlier, is represented in the accompanying wood-cut (Fig. 3).

"All the available evidence tends to show that this Desert Sandstone did at one time cover nearly, if not quite, the whole of Australia, with the probable exception of the south-eastern corner of the Continent from the Cordillera to the ocean. The journals of the two Messrs. Gregory in their expedition on the north-west and north, and Goyder's description of the new settlement of Port Darwin, all bear evidence to the continuity of this so-called "Desert Sandstone" over all the extended areas investigated by them, where denudation has been resisted by local peculiarity of structure, or other special causes. Frank Gregory, in his description of the geological peculiarities of that portion of the Nichol Bay country that came under his observation during his exploring expedition of 1861, observes that 'it consists of a series of terraces rising inland for nearly 200 miles, more or less broken up by volcanic hills towards the coast.

"The first belt averages from 10 to 40 miles in width from the sea, and is a nearly level plain, slightly ascending to the southward, with an elevation of from 40 to 100 feet, the soil being generally either light loam or strong clay, according as it is the result of the granite rocks that occasionally protrude above its surface, or of volcanic rocks of black scoria that frequently interrupt the general level.

"Proceeding inland for the next 50 or 60 miles is a granite country that has been originally capped with horizontal sandstones, and has an elevation of about 1000 feet. This range terminates to the southward in level plains of good soil, the produce of the next series or more elevated country ; whilst towards the northern edges the granites and sandstones have undergone great changes, through the action of numerous trap-dykes, that have greatly disturbed the surface, producing metamorphic rocks, some resembling jasper, and others highly cellular and scoriaceous.'

"In about Lat. 22° on the meridian of Nichol Bay, he came upon another and more elevated range, trending away to the S.E., having an altitude of 2,500 feet above the sea.

"This, unlike the last section, has a southern escarpment of 500 or 600 feet, and an average breadth of eight or ten miles ; it

consists of *horizontal sandstones and conglomerates*, which have undergone comparatively little change."

In Mr. A. Gregory's report on the results of his expedition up the Victoria River in 1855, he described a sandstone which Mr. Daintree identifies with his "Desert Sandstone." He says the specimens from the Victoria River agreed exactly with those from the Desert Sandstone of Queensland, and were undistinguishable one from another, "while the same sandy soil, the same hostile *Spinifex** (*Triodia*), the same fatal poison plant† mark its presence from Perth to Cape York. In Queensland the upper beds are ferruginous, white and mottled sandy clays, the lower being coarse alternating grits and conglomerates; the extreme observed thickness has not exceeded 400 feet. A characteristic view of the Upper Desert Sandstone beds is shown in Betts' Creek.

"Whether these are marine, lacustrine, or estuarine deposits, there is hardly sufficient evidence to show; the enclosed drift-wood as before observed giving no clue.

"A single shell (*Tellina*) found in a bed of horizontal limestone at the head of the Gregory on the Barkly Tableland, and forwarded to me by the Rev. W. B. Clarke, of Sydney, would, if belonging to this series as it probably does, give reason to believe that the lacustrine condition may be eliminated." (Daintree, op. cit., p. 277.)

It is now ascertained that the limestones on the Barkly Tableland do not belong to the Desert Sandstone formation at all, but to the great Cretaceous formation of Central Australia.

In Mr. Daintree's essay a section is given of the upper valley of the Victoria River. This section shows: (1) Desert Sandstone, in massive tableland and flat-top outliers covering (2) basaltic or trap rocks, which sometimes lie above the sandstone through an

* The species commonly called *Spinifex* in Australia, has been confused by some strange mistake with a grass which bears that name, but so entirely different from the Australian desert grass that it is as well to point out what that difference is. The true *Spinifex* are spreading or creeping hard branching grasses growing in the loosest sand by the sea-shore only, forming large tufts with dioecious spikelets, the leaves being sometimes smooth and sometimes covered with a silky pubescence. Besides three Australian species which are entirely marine, there is a fourth very closely allied to one of the Australian species, widely spread along the sandy sea-shores of tropical Asia. *Triodia* on the contrary is entirely a desert prickly grass, with leaves as sharp and as stout almost as needles. There are six species, supposed to be distinct from one another, in Australia, the two commonest being *T. pungens* and *T. irritans*. Besides the Australian members of the genus there is a common European *Triodia* and a few African species.

† The poison plant is *Gastrolobium grandiflorum*, F. v. M., not confined unfortunately to the Desert Sandstone.

overflow ; (3) hard sandstones and grey and blue slates, which from their lithological character Mr. Daintree supposed might be classed as Devonian. These beds were highly inclined, and were supposed to be the underlying basis of all that part of the country.

My own explorations in the valley of the Victoria River confirm generally the correctness of Mr. Gregory's ideal section as far as its leading features are concerned, with the exception of some alterations in the details of the so-called Devonian rocks.

Mr. Jack in his *Handbook of Queensland Geology** devotes Chapter ix. of that work to the Desert Sandstone, from which I make the following quotation :—"This remarkable formation must at one time have covered at least three-fourths of the colony of Queensland, as well as a great part of South and Western Australia. The waters in which it was deposited, had for their eastern shores the cordillera of the palæozoic rocks, which look down upon the Pacific. The deposit filled up the inequalities of the denuded surface of the rocks of the "Rolling Downs ;" while the Mackinlay and other ranges lifted their peaks as islands above the waters.

"The base of the Desert Sandstone on the western side of the Cordillera rests unconformably on the "Rolling Downs" formation, at an average elevation of about 1,800 feet above the sea level. In the south-western part of the Colony its elevation is probably not more than 1000 feet. In the York Peninsula it steals gradually downward, till it reaches the sea at Temple Bay, and covers the Peninsula from the Pacific to the Gulf of Carpentaria. In the east, important fragments of the Desert Sandstone rest, at a considerable elevation on the Bowen River coalfield, and on the auriferous rocks of Cania and Croombit. At Maryborough and Moreton Bay, sandstones which have been referred to the Desert Sandstone come down to the sea level. The formation has suffered extremely little disturbance. It is almost always found in horizontal beds, which form table-lands, with terraced edges. It consists mainly of siliceous sandstone and conglomerates. Among the sandstones thin beds of coal occur to the north of Cooktown. A thick bed of coal or oil-shale has recently been discovered on Bullock Creek, near the Northern Railway. The sandstones are mainly white, but red beds are largely developed in the York Peninsula. The latter form fair pastoral country ; but the greater part of the formation justifies the name of "Desert Sandstone" given to it by Daintree. It grows, as a rule,

* Colonial and Indian Exhibition, London, 1886. Queensland, its Resources and Institutions. Essays prepared by the authority of the Executive Commissioners in Queensland. *Handbook of Queensland Geology*, by Robt. L. Jack, F.G.S., F.R.G.S., Government Geological Surveyor, Brisbane, 1886.

worthless grasses, mainly *Spinifex*, and is thickly covered with rather stunted timber.

"Opals form the chief commercial product of this formation. They occur in nodules of ferruginous siliceous sandstone and siliceous ironstone. Although the majority do not exactly meet the definition of "precious opal" insisted on by jewellers, they are not less beautiful. A change in popular fancy, or the eradication of prejudice, is all that is required to make the Queensland opals as valuable as the most appreciated gems from Hungary. Among their chief sources are the Opal Range, the Winton, the Mayne River, the Canaway Range, Bulgroo, Nickavilla, and Listowel Downs. A fine collection is to be displayed by Mr. Bond at the Exhibition.

"The Desert Sandstone attains a thickness of 300 to 400 feet on the west slopes of the Coast Range. In the west of the colony however it dwindles to 50 or 60 feet. The Desert Sandstone affords a most impressive instance of denudation. The most casual observer, standing on the edges of one of its table-lands, cannot fail to be struck with the obvious former connection of the terrace-edged tablelands which meet the eye on all sides. This formation, geologically so new, is left only in isolated fragments, and does not cover in Queensland one-twentieth part of the area over which it once extended.

"The Desert Sandstone has yielded little but plant remains, chiefly fragments of silicified wood. Mr. Norman Taylor, late of the Geological Survey of Victoria, who accompanied Hann's Exploring Expedition, however, found in it at Battle Camp, near Cooktown, some fossils which Mr. R. Etheridge, Senr., described as 'a *Hinnites* like *H. velatrix*, and an *Ostrea* like *O. sowerbyi*, Eth.' Mr. Etheridge, however, thought that the fossils were drifted specimens lying on the surface; which Mr. Taylor assures me was not the case. In confirmation of Mr. Taylor I have the unquestionable testimony of Mr. A. C. MacMillan, that he himself had seen fossils in the locality referred to by the former gentleman. In any case, however, the fossils are insufficient by themselves to determine the age of the deposits.

"In his paper on the Geology of Queensland, the late Mr. R. Daintree first referred in 1872 to a series of rocks occurring at Maryborough, and containing fossils which, in the appendix to Daintree's paper, Mr. Etheridge, Senr., named as follows:—*Cyprina expansa*, Eth.; *Trigonia nasuta*, Eth.; *Crenulata gibbosa*, Eth.; shell resembling *Lucina (Codallia) percrassa*, Stol.; *Culcullæa robusta*, Eth.; *C. costata*, Eth.; *Nucula quadrata*, Eth.; *N. gigantea*, Eth.; *Tellina marieburiensis*, Eth.; *T. sp.*; *Avicula alata*, Eth.; *Natica lineata*, Eth.; *Panopæa sulcata*, Eth.

"Mr. Etheridge placed the Maryborough beds (which lie in the Burrum River Coalfield) below the Hughenden and Marathon beds. There is, however, no stratigraphical evidence whatever in support of this, and it is obvious from the number of new species, that the co-relation of the Maryborough beds with any European horizon rests on very insecure grounds.

"Mr. Gregory* says that the Maryborough beds merge upwards into the Desert Sandstone, 'which appears as a thin covering to the older rocks along the sea-coast from the Burnett River to the Logan River.' If we could be sure of the identity of the 'thin covering' with Desert Sandstone, the relations of the Maryborough beds would be clearer; but the point is a doubtful one. I am inclined to regard the 'thin covering' as a newer deposit than the Desert Sandstone—possibly post-tertiary. But the solution of the difficulty must await the production of further evidence.

"I have in the meantime coloured the Maryborough beds, provisionally, as Desert Sandstones, but the arrangement is merely a temporary convenience.

"Leaving the Maryborough beds out of the question, the only direct evidence bearing on the age of the Desert Sandstone is that it lies unconformably on the "Rolling Downs" formation. It may be the equivalent of the Upper Cretaceous.

"In the arid western interior, the tablelands of Desert Sandstone serve one useful purpose. They are 'sponges' which absorb the rainfall, and let it out in springs at their junction with the underlying more argillaceous rocks of the 'Rolling Downs.' Some of these springs were still active, at the end of 1885, after three years of drought."

From the time of Leichhardt, North Australia was generally regarded as a plateau of Desert Sandstone, with a precipitous face on its northern edge. Sometimes these cliffs on the edges of the table-land abutted on the ocean, and sometimes a low flat land very gradually rising from the sea led up to the plateau, varying in width from 1 to 100 miles. Where the Sandstone abuts upon the sea-coast, it gives rise to a precipitous series of gorges like the Sydney Harbour, and its character at a distance is like the Blue Mountains. Leichhardt in exploring the Alligator River to Port Essington, had much difficulty in finding a practicable place where he could descend from the plateau. By some mistake in transcribing his notes, he has been quoted as saying that the height of this plateau varied between 1,800 and 800 feet, but it is stated that an attentive examination of the original MS. journal shews that the height given is 300 feet only. Stuart

* Geological Features of the South-Eastern Districts of Queensland. Brisbane, 1879. By authority.

appears also to have experienced considerable difficulty in descending from the plateau on to the alluvial margin of the north coast, though in his case there were many rocky gorges at hand. He says in his journal of 10th July, lat. 13° 24':—"At half-past one crossed the table-land, *breadth thirteen miles*. The view was beautiful. Standing on the edge of a precipice, underneath, lower down, a deep creek thickly wooded. * * * * We had to search for a place to descend, and had great difficulty in doing so, but at last accomplished it without accident. The course of the table-land is about N.N.W. and S.S.E., and the cliffs appear to be from 250 to 300 feet high. We were now without doubt upon the Adelaide River." Other instances of the character of the edge of the table-land need not be given, for it would appear to be very much alike in the various places where its limits have been been crossed by Gregory, Burke, Landsborough, Walker, and McKinlay. The southern edges of the plateau have sometimes the same precipitous faces as the northern.

Having made an attentive examination of much of the coast line between Carpentaria and the Victoria River, I am able to speak positively as to the nature of the formations which are met with. The physical structure of this part of the Australian Continent is best described in the words of my report to the South Australian Government in September, 1886, as follows:—

"Before proceeding to give details of the geology of the Territory, it will be necessary to correct an erroneous idea which has prevailed as to the physical structure of this part of the continent. That idea has been that the plains, after rising by an easy slope from the sea southward, reach points at varying distances where they are covered by a rampart of sandstone, about 600 feet in height. This rampart is supposed to be the edge of the great plateau of the interior or continental Australia. In other places the table-land is supposed to be 800 feet in height above the plains, and 1,800 feet above the sea. Latterly this plateau has been called by the name of the Desert Sandstone, and is supposed to cover most of the older formations, and to cut out as it were all the older and mineral deposits. Whether it does so or not in the far interior I cannot say, though I am inclined to think not. Where I have been there is no such thing as a continuous table-land. Patches of broken table-land occur frequently at the sources of rivers and creeks, but they are only patches, often no more than ridges; if they are more than four or five miles in width they descend as an inclined plane to the valley of the next large watercourse, where the older formations generally crop out; their height varies between 120 and 300 feet; once only have I seen a plateau of 370 feet in height. At its northern, which is always the broken edge, it was less than half that.

elevation. Leichhardt is said to have found on his descent from a plateau, precipices 800 feet high, but this is now known to be an error in transcribing his notes.

"The name of Desert Sandstone is unfortunately chosen for these table-hills or flat-topped ridges. Sandstone there is in abundance, besides ferruginous sandstones and sandstone conglomerates, but they are not always in the cliffs, or only form a portion of them. Nearly all the cliffs are capped with compact magnesite or carbonate of magnesia, from 10 to 40 feet in thickness, sometimes ferruginous, or quite pure and white. The cliffs are made up of various formations, and it is incorrect to call them Desert Sandstone. Here are the proofs:—At Yam Creek, about two miles south from the telegraph station, the line passes through a gorge, bordered on each side by precipitous cliffs, varying in height from 130 to 200 feet. The bottom of the valley is 335 feet above the low water level of the sea. At one place where I ascended the cliffs they were 130 feet high, of this 90 feet was granite, 10 feet waterworn quartz conglomerate, ferruginous magnesian sandstone 16 feet, pure white magnesite 14 feet. Two miles further the cliffs were 140 feet high; of this 80 feet was granite, and 50 feet a highly ferruginous sandstone horizontally stratified. At the head of the Mary the cliffs were 200 feet high, 30 feet of this was a fine-grained white sandstone, formed of wind-blown sand, the grains under the microscope being rounded and abraded like the sands of the Sahara; above this was 170 feet of pure white magnesite. The valley was composed of palæozoic slates and felsites.* Other instances will be given in the body of this report.

"At the gorge at Yam Creek the table-land is a mere ridge. At M'Minn's Bluff (270 feet above the plain) it is an outlier, broken up into detached hills; it is the same at Mount Shoobridge. At the head of the Mary the cliffs are about 200 feet high, then there is an inclined plane, rising 100 feet higher in six miles; then for four or five miles an inclined plane descends for 40 feet a mile, until Kekwick's Springs, on a tributary of the Katherine, is reached. Again, on the heads of the Katherine, a sandstone table-land was ascended to a height of 250 feet, but it was a mere ridge, with a valley 50 feet deep on the east side, with large springs of fresh water, giving rise to a creek. Crossing, this led to an inclined plane of four miles, falling about 25 feet to a mile; this brought us to a gully, the head of Maude Creek, where we were in about three miles almost on the level of the Katherine, and in auriferous country again.

* A compact mixture of quartz and felspar without any traces of crystallization.

"It will appear, therefore, that as far as I have seen, the Desert Sandstone so called, is confined to numerous small patches of a newer formation of moderate thickness, which does not cover the older rocks to any large extent. Yet this character would not be suspected from its aspect as seen from a distance. I do not wonder in the least at earlier explorers having been led into error with regard to it. When one ascends to the summit of any moderate elevation, the sloping base, white cliffs, and flat summits of these hills are conspicuous objects, and there extend from these, level plains of apparently unlimited extent. But none of the hills are high enough to command an extensive view: if they did, other hills would be seen cropping out. The mistakes which have occurred have been for want of careful measurements, or giving descriptions from distant views rather than from actual exploration and a close examination of the nature of the rocks. I have also had the advantage of the 125 miles of levels taken for railway purposes.

"It must be also borne in mind that the magnesian and sandstone formation never rises to the height reached by the paleozoic and metalliferous rocks. Thus Mount Wells (mica slate, with tin and copper veins) is about 900 feet above the level of the sea; Springhill—gold mine, 800 feet; the Union, 700 feet; Jensen's, 800 feet, and so on. None of these heights are ever attained by the flat-topped table-land. So far, therefore, from much of the auriferous formation being covered by it, from its nature and elevation that formation is far more likely to crop out above it.

"From what has been said, it appears that the term Desert Sandstone is a misnomer. Whether the formation is the same as that which was described under that name by Mr. Daintree, in Queensland, is not certain. There are here three kinds of rock:—(1) A red sandstone, composed almost entirely of rounded grains of sand and ferric oxide; the appearance of these grains and the stratification of the rock show a desert origin, such as blown sands present. (2) Magnesite and silicate, and ferro-silicate of magnesia; this rock is pure white and yellow, or mottled fiery red. These rocks I believe to be derived from the decomposition of fine volcanic ash, containing much olivine, or otherwise rich in magnesia. South of the Edith River there is a large volcanic area, with high basaltic hills and much vesicular lava, all rich in olivine. When these volcanoes were in activity (in Miocene times?), the fine dust from the ashes covered a large area; thus we find these flat-topped cliffs of magnesite lying on granite rocks and on slates (Mount Shooobridge). (3) The third formation included under the name of Desert Sandstone, is a fluvatile conglomerate; it is only found on the banks of streams;

it is an extremely hard sandstone, horizontally stratified and cross-bedded, with the finer laminations marked by black specular iron; it contains much rounded and water-worn quartz gravel, from the size of a small pebble to that of a man's head. This formation is much broken into immense boulders and rocks of most fantastic shapes. It is very hard, but being full of cracks and fissures weathers easily, and gives rise to a surprisingly rough country, almost inaccessible to explorers. It is composed of sandbanks and river boulders, which have hardened since the rivers cut through them. Like the banks of the rivers of the present day, they rise occasionally 100 to 300 feet above the bed, and extend two or three miles on either side. Mount Douglas is an instance of this formation, and in the ranges on the upper Katherine River it is developed to a large extent.

"The above description of the table-lands and other formations will help much to understand the physical structure of the Northern Territory, which is as follows:—

"The coast is very low and flat, and rises by a gentle incline at the rate of about five feet a mile. But there are low ridges of quartzite, slate, and sandstone, rising almost from the sea level to a height of 50 feet or more, gradually increasing to 100. They run north and south, that is, generally speaking, with a general trend to the eastward, as they are traced to the south. From these ridges, small creeks and tributaries take their rise, and descend towards the main valleys, in which there are permanent waters.

"The following heights and distances will give a better idea than any description:—

	Distance from Palmerston.			Height above sea.
The Elizabeth ...	25 miles	15 chains	...	52.56 feet
The Berry ...	35 "	70 "	...	76.84 "
The Darwin ...	43 "	45 "	...	93 "
The Finnis ...	45 "	5 "	...	184 "
The Stapleton ...	69 "	64 "	...	239.50 "
Peters Creek ...	74 "	40 "	...	188 "
The Adelaide ...	76 "	58 "	...	183 "
Burrell's Creek ...	80 "	12 "	...	177.50 "
Calder's Creek ...	88 "	36 "	...	199 "
Bridge Creek ...	94 "	59 "	...	322.50 "
The Howley ...	99 "	"	...	250.50 "
Yam Creek ...	111 "	69 "	...	328 "
The Margaret ...	114 "	"	...	340 "
Foelsche's Creek ...	122 "	66 "	...	318 "
The McKinlay ...	124 "	68 "	...	304 "
Snadden's Creek ...	131 "	10 "	...	404.50 "
Lady Alice Creek ...	135 "	"	...	484 "
Pine Creek ...	145 "	79 "	...	657 "

"The distances are by the railway line, and the heights above low water sea level at the railway crossings of the various streams.

"It will be seen that the heights begin to increase rapidly from the 95th mile, and continue to Pine Creek, so that the average rise, which is about five feet per mile, is less than three feet per mile for the first 100 miles, and more than six feet per mile for the next 50 miles. This is owing to the commencement of ranges which are connected with most of the mineral country in the Territory. These ranges are a series of parallel ridges having a south-south-easterly trend, and rising to a height of from 200 to 600 feet above the plains, though the latter height is exceptional. This mountainous area is about 20 miles in width, from east to west, and 40 miles in length from north to south; in it are contained the sources of most of the small tributaries of the Adelaide and Mary, which are rivers with a north and south direction. The Adelaide may be said to take its rise in the midst of this chain, and the Mary to the eastward and southward.

"The ridges and ranges are separated in their northern portions by somewhat wide alluvial flats or valleys, but to the south-east the ranges are closer together, higher and more abrupt, besides being exceedingly stony and barren. Thus the country south-east from Mt. Wells, as far as the Mary River, is exceedingly rugged, and many of the ranges and valleys almost inaccessible. The most closely metalled road would not be more deeply and thickly covered with stones than the valleys and ranges. Several long and high spurs (500 feet above the plain) are continued to the eastward into the valley of the Mary River, but at about 100 miles from Southport the ranges decline to the level of the plain.

"At the sources of the Mary, the river takes its rise amid flat-topped cliffs of the most picturesque description. The view along the stony white gorges has few parallels in Australia. The valley of the river is hemmed in by straight cliffs of castellated outlines some 150 or 200 feet high. There is often a slope or talus at the bottom, but they are only accessible in a few places, and the valley is for the most part fertile and shaded by fine graceful palm trees; springs bubble out from the shady thickets at the foot of the cliffs, giving rise to streams many feet wide, and deep from their sources. The valley is strewn to a bewildering extent with huge boulders and masses of rock, which have fallen down from above, because the magnesite is very brittle, with a foundation of loose and friable sandstone. Thus no very long time would be required for the springs to crumble and break away the edge of the table-land, or scoop away the valleys as we see them now.

"The springs, therefore, I believe to be the origin of the cliffs and gorges at the heads, not only of the Mary but of the West and South Alligator Rivers, and many besides. The magnesite

and sandstone strata are very permeable to water. The heavy rainfall of the wet season easily drains through the strata, and bubbles out at the base, where it has weathered and broken it away into abrupt, precipitous, and fortress-like hills."

Beyond the Mary to the eastward there is table-land of a very broken character, forming scenery which has few parallels I think on the face of the earth. To use the words of my journal at the time of my visit—

"There was no high hill near us, but from the summit of the steep slope above the camp a fine view was to be obtained. A fine view and a strange one; indeed I doubt if there be another like it in the world. All around there is such a sight of cliffs and gorges, isolated hills and flat-topped hills, hills like lighthouses, hills like fortresses and bastions, and city gates, and ruined palaces—in short, like anything and everything except the common-place and monotonous. And then there were such combinations of colour—white cliffs, red cliffs, blue cliffs, striped cliffs; in fact, I am afraid to go on for fear of overtaking the confidence of my readers. I could have gazed and wondered at the scene for a long time, and still found plenty to wonder at and ponder over, for it is a prospect about which one could imagine anything. It seemed to me so lifelike and so deathlike, so real and so imaginary, that I knew not what to compare it to. One could hardly believe that such startling shapes, so like the work of man, could be entirely a freak of nature, and then the utter absence of anything like human life about it suggested all sorts of associations. It looked very barren, too, but this it certainly was not, as we found on a nearer inspection. One thing this view from afar impressed on us was the difficulty we should find in crossing such a country. The gorges seemed as difficult to descend into as Sindbad's Valley of Diamonds, and once in them the problem was to get out again. It seemed like expecting horses to be able to climb up a wall. However, it was not so bad as it looked."

I now proceed to deal with the formations of Desert Sandstone. They may be arranged as follows :—

1. Magnesian sandstones, magnesite or carbonate of magnesia and ferruginous magnesites from 40 to 50 feet. This stratum is not always present.
2. True siliceous sandstones, quartzites, and loose sand-beds scarcely indurated into a rock mass.
3. Fluvatile drifts of a very broken character 500 to 600 feet thick at greatest thickness, mostly connected with the present fluvatile drainage of the country, but forming valleys of much greater width.

Before dealing in detail with these different formations, it is important to point out a fact which has a significant bearing on their origin. If a geological map of any portion of the interior is consulted, it will be observed that in many instances where recent volcanic rocks are marked, they are seen to be associated with what is called the Desert Sandstone. Sometimes, as at Dubbo, Wellington, Warburton, Sofala, &c., it is called Hawkesbury Sandstone, but the connection with the volcanic rocks is indisputable. The position that these sandstones always occupy with reference to the points of ejection of the recent volcanic rocks, shows that they are dependent upon them, and they are sometimes intercalated with them as I shall show hereafter. The high lands of New England, which contain large manifestations of recent volcanic rocks, are rich in these sandstones too, which the late Mr. Lamont, one of the able assistants of Mr. Wilkinson in the geological survey, early recognised as ash-beds. In the interior on the Lachlan, Darling, and the back country between both, there are many instances of Desert Sandstone occurring as detached outliers, but always so near recent volcanic rocks that they cannot be otherwise than connected with them. Particular instances of this will be given further on, but it is important to note the facts themselves at this stage of the paper.

I will now proceed to give detailed descriptions of the various formations in the Desert Sandstone which I have enumerated above.

Magnesite deposits—I venture to suggest that we have in these strata remains of a volcanic origin which have accumulated during a long period of volcanic activity. The beds seem to have occupied a wider area than they do now. They vary in thickness from 10 feet to 500 or even more, though the thickest deposits measured by me did not exceed 40 feet. They are now formed into a compact and various coloured stone, consolidated no doubt by chemical action and decomposition as well as pressure.

If my suggestion as to the volcanic origin of these magnesite beds be accepted, we have not very far to seek for volcanic points of ejection, from which they may have proceeded. Geological readers need scarcely be reminded of the great mass of trap-rocks which encircles the edge of the continent of Australia, with perhaps the exception of the south-west side. Western Victoria seems one of the recent foci of activity, the latest disturbances having occurred at no great distance from the mouth of the river Murray. Very recent outbursts have also occurred about the middle of the east coast, in the latitude of Moreton Bay, where volcanic emanations and existing shells are mingled together on the coast. It is difficult to form an opinion as to the relative

ages of the volcanic rocks and the so-called Desert Sandstone, for both as yet have been imperfectly surveyed. There are many areas of volcanic rock, such as basalts, diorites, and other igneous or trap formations in the Northern Territory; but if we regard the magnesite as an ash deposit, it is not easy to say as yet to what portion of the volcanic history they owe their origin.

The uppermost magnesite strata form a rock which is very much decomposed. They are seldom uniform for any great extent either in colour or material; pure white, cream-colour, mottled, and various shades of purple and red prevailing in ever varying tints. There are few marks of stratification, but long divisional lines which indicate protracted periods of rest in their accumulation. If we accept the volcanic origin we may suppose that the craters or trap rocks connected with such deposits must have been very rich in magnesia, the most probable source of which would be olivine. About ten miles north of the Katherine River there is an area of volcanic rocks, the limits of which I was not able to examine. In the bed of a creek near which I had formed my camp there was an appearance of trap rocks, amongst which there was a basalt very rich in olivine. It cannot be said exactly, however, from whence the magnesite proceeded. It may be due to some such rock as suggested. The deposit is too extensive to have been derived from freshwater action on the underlying rocks which are rich in mica, and probably other magnesian minerals. A marine origin is of course out of the question.

The volcanic deposits which are found on the Katherine River are not the only ones in Arnheim's Land. A large area occurs to the west of Port Darwin, and a very large volcanic district is found at the head of the Victoria and of the Fitzmaurice Rivers. The rocks here exposed are of modern character and probably belong to several distinct periods, certainly to two, of which there is constant evidence in the continent of Australia. I have mentioned a significant fact connected with the strata as far as my observations extend; namely, that wherever they are developed trap-rocks are associated with them. If it will be borne in mind that I am not extending these observations beyond the limits of my own experience, I might add that the converse of this proposition is true, that is wherever there are volcanic rocks there are extensive accumulations of volcanic sand; though what I am presuming to be ash deposits are not always presented in the form of magnesite.

It is not easily understood why these magnesite deposits have been preserved so extensively in North Australia, and are to be seen, rather rarely, in connection with the Tertiary trap rocks elsewhere. Circumstances, we may presume, have combined for their

preservation in a way which I shall try to explain hereafter. Yet it may also be inferred that the absence from other places may be more apparent than real. An attentive examination has not been made, or these ash remains would possibly have been much more extensively recognised. It must be borne in mind that Mr. Jack the Government Geologist of Queensland, and myself have been the only geologists who have paid attention to the matter, and attributed to these strata their true character. I may say, however with some confidence, that though few ash beds have been recorded as occurring on the south of the Australian continent, unless in seams that are quite insignificant, it is only because the true nature of such formations has not been understood. In the "Notes on the Physical Geography, Geology and Mineralogy of Victoria"* (p. 74) Messrs. Selwyn and Ulrich, report many important deposits of magnesite, thus :—" *Magnesite (Carbonate of Magnesia)*—This mineral is tolerably abundant in the 'kaolin' deposit of Bulla Bulla, near Keilor, at Heathcote, and generally in the Tertiary clays near Geelong, Bacchus Marsh, Western Port, &c. ; also in the surface soil along the banks of the Loddon River, near Newstead, forming nodules of all shapes and sizes, from that of a pea to several inches cubic. According to analysis these nodules are however, not composed of pure carbonate of magnesia, but contain small variable proportions of carbonate of lime, carbonate of iron, and clayey matter. A peculiar occurrence of very pure magnesia is observable at the Hard Hills, near the junction of Jim Crow Creek and the Loddon River. It appears like an annular outcrop of a bed of nearly one foot in thickness round the base of a small hillock, composed of older Pliocene gold drift, but extends barely a few inches beneath the surface. This outcrop consists of an aggregation of nodules of all sizes, from several inches diameter to even fine roundish grains, like oolitic sand. Some of the nodules are extremely hard and homogeneous, but the generality consist of roundish particles of pea-size, with obscure rhombohedral planes, sometimes closely, but in most cases very loosely adhering together. The origin of the mineral appears to be due to the action of the carbonic acid of the atmosphere on a seam of white soapy clay which contains a large percentage of silicate, and perhaps hydrate of magnesia, and would crop out now where the *magnesite* appears. Where the atmosphere could have no access to the clay, there is a total absence of *magnesite*, whilst on the other hand, in places where the clay has been exposed to its influence, even in the most recent times—for instance in the drift heaps from several shafts on the hillock—the small white grains appear in profusion like white sand artificially strewn over the surface."

* Intercolonial Exhibition Essays, Melbourne, 1866.

T—November 7, 1888.

I have very little doubt that in many of the places here enumerated, the magnesite is derived from volcanic ash, probably in a decomposed condition. The deposit observed at Hard Hills on the Loddon River belongs to the great volcanic outbreak, which has covered the country with basalt more or less uninterruptedly all over Western Victoria, and which includes a large number of extinct volcanoes.

Prof. Liversidge in his "Minerals of New South Wales,"* thus speaks of magnesite (p. 165):—It is found in New England in various places, and upon the diamond fields at Bingera, co. Murchison (where the mineral has a peculiar reticulated surface and mammilated form) and near Mudgee. When impure it is of a grey or grey-brown colour, but when pure it is a dazzling white, compact, tough, and breaks with a flat conchoidal fracture. . . . Other localities are Kempsey; Mooby Gully, Lachlan River; Some co. Brisbane; Louisa Creek and Lewis Ponds Creek, co. Wellington; Barabba, co. Darling; Tumut; Gulgong; and Warrell Creek, Nambuccra River.

We might include also to some extent serpentines as well as magnesites, though I have not met with any such deposits of an extensive character that seemed attributable to volcanic ash.

One of the main sources of the magnesium salts would be doubtless from volcanic rocks, and particularly basalts containing olivine. By many of the older mineralogists only those volcanic rocks which contained olivine were regarded as true basalts: at any rate basalts containing large quantities of olivine are extremely common. Thus Messrs. Selwyn and Ulrich, in the work already referred to, state under the head of olivine or chrysolite (op. cit. p. 66) that "this mineral is so common in the newer basalts (except where the latter appear as true 'dolerites') as to deserve to be regarded as an essential constituent of the rock. It generally appears disseminated in small angular grains of light apple to blackish-green colour; but at many places, especially in the neighbourhood of basaltic craters and points of eruption (Mount Franklin, the Anakies, Gisborne Hill, the Warrion Hills, &c.) it occurs in irregularly shaped, or sometimes sphaeroidal masses, of both fine and coarsely granulated texture, and from one to five, in some instances (Anakies) to even twelve and eighteen inches in diameter. Crystals have not been observed as yet. An analysis by Mr. Daintree of light green olivine from the Anakies yielded:—

Silica ...	...	...	42.60
Protoxide of iron...	...	...	7.36
Magnesia ...	...	...	50.00

99.96

* London, Trübner & Co., Ludgate Hill, 1888.

According to all appearances this mineral easily decomposes through atmospheric influence, assuming at first chatoyant colours, then turning to reddish-brown, and ultimately, beneath a thin coating of hydrous oxide of iron, changing to a brownish-red mica ('*Rubellane*')."

Prof. Liversidge (op. cit. p. 117) gives many localities for the occurrence of olivine, besides many magnesian products which may be supposed to have been derived from the decomposition of chrysolite in basalt; but it is not necessary to cite the passage. It may be mentioned however that at the railway cutting along the Main Range, about 100 miles west of Brisbane, both tunnels and cuttings are made through ash deposits derived from a large extinct volcano on the edge of the Darling Downs. Over the ash-bed there is a distinct overflow of basalt which is conspicuously full of olivine, the masses being sometimes of large size. The section is very instructive, for the ash-beds are partly decomposed and in some respects remind one of the Nepean Sandstones near Sydney, New South Wales. At the junction of the lava stream, the ash-beds are conspicuously discoloured from the action of the heated basalt, forming long lines of red, pink, and other colours, like the effect of burning in a kiln.

Though the ancient character of the ash-beds of North Australia may be inferred from their chemical metamorphism, yet they are the newest deposits that are to be found in this region. They lie on the top of all other formations which they cover, as already stated, to a varied depth. The following description of some of the beds exposed is taken from different portions of my report.

McMinn's Bluff.—The road from Pine Creek by the side of the telegraph line passes along a valley formed by a flat sandstone table-land on the west side and a low slate range on the east side. The table-land forming the western boundary of the valley is at its southern end a long narrow range, covered with a stratum of stone, which stands out like a rampart some 30 or 40 feet thick, giving a castellated appearance to the flat-topped hills. As the range is followed north it is broken into three or four small outliers of white and red colours. They look like ramparts and fortresses, and are of very picturesque appearance. They all have a steep incline for about two-thirds of their height, and then become rugged for some distance, and then suddenly precipitous for 30 or 40 feet to their flat-topped summits. One of these hills is of fiery red on the top, and it is joined by a low saddle to another outlier, which is capped with picturesque cliffs which are white.

The section of these hills is as follows:—Granite, 90 feet at least, it may be more, but the line of junction is concealed by weathered masses of rock, which have fallen down from the cliffs. Then follows 100 to 150 feet of coarse red sandstone. Then 30

to 40 feet of magnesian silicate, making a total at the highest of about 270 feet above the plain.

The coarse red sandstone lies in horizontal strata. It consists of large quartz grains imbedded in a reddish-brown cement. Its materials have no apparent connection with any rock visible in the valley now.

The upper stratum is a compact rock with small vesicles. It is either creamy-white, yellow, or mottled a deep red-brown, with streaks and veins of lighter colour. There is a concretionary character about its decomposition, which makes it break up into a number of small red rounded pebbles like pea iron ore. But this is not always visible, only where there is much iron oxide. In other places it is a pure white, and consists of a magnesian silicate. The mottled character of the upper stratum is very remarkable, varying through all the shades of livid red, purple, yellow and brown, more in the shape of rounded clouds than anything like crystallisation. No doubt it is the effect of the action of water upon the iron ores contained in the ash deposits.

The Shackle Gorge.—The section visible near the old telegraph station at Yam Creek, proceeding from above downwards into the valley is as follows :—

Magnesite	...	...	14 feet.
Sandstone, purple and red stains	...	16	„
Waterworn conglomerate	...	10	„
Granite	...	90	„

130

In this section the magnesite is of the usual mottled and pisolitic character. The sandstone is derived from granite sand of a fine character, the grains being angular and not at all rounded as if by eolian action. The granite is pink with very coarse felspar of orthoclase and muscovite mica. It apparently belongs to the great fundamental granite bed which crops out through all North Australia.

Douglas Springs.—This section is taken from the sources of the Mary River in the narrow gorges of much broken tableland in which that river takes its rise.

Magnesite	...	...	130 feet.
White sandstone	...	20	„
Red sandstone	...	50	„

200

There is no appearance of the granite formation either here or for some considerable distance southward. The magnesite is of the usual character and variously coloured, many cliffs being entirely white, without any red mottling. The sandstone is friable

and under the microscope shows an eolian character, which is like a true aerial sandstone. The grains have been photographed as seen by an inch objective, and have been figured at plate xxii., fig. 4. It is seen that they have a perfectly transparent appearance, being rounded almost as much as the sands of the Sahara. For comparison the grains of the ordinary sandstone are figured at plate xxiii., fig. 8. This is a seam of small thickness as appears from the above figures. The red sandstone underneath it is of a somewhat less rounded character.

From the above sections it appears that the plateaux are only to a certain extent formed of sandstone. It may be asserted from all I have seen of the formation, that the greater portion of this tableland is granite, and that as the magnesian beds are traced northward they thin out or disappear.

False-bedded Siliceous Sandstones.—But if the general character of the magnesite rocks suggests their origin it is not so easy to deal with the sandstones which underlie them. These need hardly be described. They are brown, reddish, purple-red, and yellow sandstones with thick more or less horizontal layers and false bedding between. To those who are familiar with the Sydney sandstone, no other description will be necessary than to say that they are similar in stratification and the mode of occurrence.

The great mass of the Desert Sandstone formation is of this character, and in many places there is no appearance whatever of magnesite strata. The only variation that I can trace amongst this sandstone is that some of it has the grains rounded as if by some aerial attrition, while in other portions they are fine and angular, containing small irregular fragments of white quartz and felspar, not more than an inch in diameter, and mostly less than half that size. Sometimes these are crowded together so as to give a conglomerated appearance, or rather that of coarse angular gravel; but there are wide areas also with nothing but finely grained sandstone varying only in its many colours.

These sandstones have been a great problem to every geologist who has studied Australian rocks. The Desert Sandstone was very perplexing to Mr. Daintree, just as the Hawkesbury Sandstone was to the eminent Chas. Darwin. It is now nearly eight years since I wrote a paper on a similar matter, and I suggested that these were sands that had been blown about loosely and accumulated in the form of dunes. It will be observed that there is nothing contrary to this idea in what I am now suggesting. The grains from whatever source they came, whether volcanic, granitic or metamorphic, may have been blown about and probably were blown about in the upper strata ere they were consolidated into stone. It may be observed also that these sand ashbeds are not always hardened into a stone. Every intermediate stage may be

met with in the interior and on the coast, from loose drifting sand of a true eolian character to hardened stone like the Sydney sandstone. At Double Island Point, about 100 miles north of Cape Moreton in Queensland, there is a sand formation some three or four miles on the south side of Wide Bay. The southern boundary of the bay is formed by two somewhat conical hills of scoriaceous rock separated by a long interval of low land from a mass of volcanic rock. All this may have been part of the ancient crater; but it is now covered with green vegetation and light timber. On the west side there is an extensive development of sand cliffs quite precipitous on the seaward side, varying between 100 and 200 feet high. I have already referred to this curious formation in the paper above mentioned on the Hawkesbury Sandstone, (read before this Society May 10th, 1882) in which I deal with it simply as a formation of blown sand without entering into the question of its origin. No one will dispute that the sands in this case are the ash-beds from the volcano extending to no great distance, but being a patch of such thick beds that there would be no way of accounting for them but for the ancient crater which is close by. The cliffs have curious undulating layers of varying thickness forming sinuous lines with laminae of sand, false-bedded and dipping at every angle up to 30 degrees. The layers no doubt mark different periods of activity. They are of various colours, giving the cliffs a ribboned appearance, white, yellow, or ochreous-red. On the surface there is a dense growth of tea-tree, with a few patches where the sand forms shifting dunes of rounded outline and great height.

In various geological essays of mine, I have referred to a formation on the south coast of Australia, especially between Port Philip and the river Murray, but always in connection with recent volcanic emanations. It is described as a rock of dark brown colour in patches of rough and compact character; at times it forms sea cliffs of considerable height. At a distance, one would imagine the rock to be divided into large strata, some 14 or 15 feet thick, with false-bedded lamination between. The material of the rocks is sandstone, but the surface consists of fragments of shells and marine remains with grains of sand and sponge spiculæ intermingled. At one time I regarded this as composed of hardened eolian calcareous sand; but a more careful microscopic examination has shown it to be an ash-bed, though sometimes it is many miles distant from recent volcanic rocks. Instances may be seen all along the coast, but fine examples near the extinct crater of Cape Grant, at Warrnambool &c. The rocks around Guichen Bay are all tufaceous, in fact there are few parts of the coast which do not show traces of the former activity of Mounts

Muirhead, Graham, Leake, Gambier; and others too numerous to mention, which occur a little way inland.

The vast accumulations of sandstone in the interior without any fossils, diversified with cañons, gorges, precipices, plateaux, and table-topped hills, indicate such an origin as I am suggesting, if we can only satisfy ourselves that the material of which this sand is composed is such as may have been derived from volcanic sources. The evidence that appears to me to bear upon the matter I will now place before my readers.

In my recent travels through Java, my attention was specially directed to the origin of the sandstones met with in that very volcanic island. The first thing that took my attention on landing in Java was the sand upon the beach, which was black and as unmistakably volcanic as anything could well be. No one could misunderstand its character, which spoke plainly of subterranean fires; just, in fact, like very recent volcanic ejectamenta on the latest extinct craters of South Australia. What this deposit would become in a few years time was plainly evident in the older beds. Close by Banjuwangi is the large active volcano of Rawun over 10,000 feet in height, and with a crater of more than five miles wide. As one ascends its torn and rugged sides the huge crevasses and terribly precipitous gullies of 1,000 feet and more reveal immense masses of beds deposited by ancient eruptions. In colour, in consistency, in material, and in stratification they very strongly reminded me of the Desert Sandstone; but I should be far from considering this resemblance as a sufficient proof of their identity. There is not a grain of sand cast forth from the bosom of the earth that is not stamped with marks innumerable to show the nature of its origin. As truly as every coin minted bears a stamp to mark the place of its coinage, so each tiny grain of dust bears its impress unmistakably. It is almost proverbial to say that grains of sand are as like one another as things can well be. But direct the tube of the microscope upon them and what a number of differences are revealed. The volcanic grain with its freshly molten certificate of character, its glassy inclusions, its gas-cavities, and its optical properties, has entirely peculiar qualities of its own which no other grain of sand in the wide world can pretend to. It is true, however, that if it has lain exposed to chemical influences from remote antiquity, its genealogy may be so obscured that only the most experienced eye could trace it, and there are very many sandstones, whose origin, volcanic or no, cannot be decided. But for modern volcanic sands no such thing is possible. The finest volcanic dust (indeed the finer the better) of anything like modern geological times is one of the easiest things to detect, and few could be mistaken in it.

In my paper on the Hawkesbury Sandstone, sands and their characters became a special subject of investigation. Thus my

attention was specially directed to the subject and thenceforth I have collected sands and sandstones all through the various colonies. What with these and the aid of friends, thousands of specimens have passed through my hands and have received what attentive examination I could give them from the microscope. Afterwards when travelling through the volcanic regions of the East, I have collected numbers of specimens as well, besides observing the manner in which the ash deposits accumulated and how the different epochs of eruption were represented by strata. I have now before me while I am writing, many specimens, not only from the hundreds of craters in Java, both active and extinct, but sand from the active craters of the Moluccas, the Philippines, Celebes, the Linschoten Islands and Japan. The list of Javanese craters alone would be a long one.

All these sources of volcanic material however distant and different in their extent, have produced volcanic sands which are one in character; though one mineral may have been present or absent, or more or less abundant in particular cases, yet the general result is the same.

It may be necessary moreover to state that sand is one of the commonest and most frequent of volcanic emanations; but sand just like sandstone may mean many different things. Sand is a term applied to finely divided particles of various different minerals; such as quartz, felspar, the various compounds of silica with quartz, alumina, magnesia, iron &c. Even when restricted to the siliceous sands alone, the term has still a wide multiplicity of applications. If the fine sand of a granite country for instance is placed under the microscope, the quartz presents a peculiar aspect which a very little experience enables one to recognise as belonging to that rock. It has a characteristic ruggedness about it with cavities and included crystals always of some size. There are sure to be crystals of different kinds of felspar, with mica and perhaps hornblende. But if the sand be recent, or in fact an ash, the quartz bears quite a different appearance. It has vitreous inclusions, though these are not always numerous, but innumerable gas-cavities; and nearly every fragment has microliths or crystallites, which are microscopic portions of very many minerals in different stages of development from an amorphous state to a complete crystal. The oddest as well as the most beautifully fantastic forms may be seen even in minute broken pieces of stone. They frequently present crystal faces, and from this the nature of many of them can be made out, and generally this is the case with the great majority; but some defy all attempts to reduce them to a geometrical form. Thus there are threads and beads, hooks and symmetrical arrangements of dots and feathered fragments. Petrologists, without attempting

to say what these may be, have made some sort of a classification by arranging them under the heads of microliths, crystalloids, trichites, and globulites. Microliths are imperfectly developed crystals, often possessing optical characters which enable their nature to be determined. In sections of certain volcanic rocks, streams of microliths with their longest axis in one direction may be seen sweeping in curves round the larger crystals and fragments. Crystalloids manifest a higher development, being bounded by curved or straight lines, and sometimes stellate and cruciform varieties; often too in the form of true crystals which can be recognised. Trichites are like hairs or fibres, more or less straight, curved, or bent in all kinds of angles and twists, twirling in the most fantastic modes round larger granules. Trichites often are lines of granules like beads in rows or in pairs. Finally the name globulites is reserved for those amorphous and roughly spherical bodies which cannot be identified with any of the other categories; though these shapeless masses are symmetrical often in their mode of grouping, and are also arranged in streams in the viscid lavas.

Now when volcanic sands are very fresh, we find all the above inclusions well represented and unmistakably present; but I regret to add that it does not take a very long time to destroy them. Chemical interchange goes on, oxidation and crystallisation accompanied with the weathering action of water, so as to obliterate most of the former characters. I wish I were able to say after having spent so much time in the microscopic examination of sands, that I have discovered any definite mark or character by which the history of the mere quartzose residuum could be determined, that is to say the nature of its former genesis; but I repeat to my regret that such evidence is not always very visible. It is true that even when the stone is apparently an aggregation of pure siliceous grains, there are always some foreign minerals left which may help to determine its origin; but it must be admitted that the evidence is not always of a conclusive or satisfactory kind. Without wishing to rely upon such facts for more than they may be worth I will here notice some that have fallen under my observation, which may help to throw a light upon the origin of these Desert Sandstones.

First of all is the shape of the grains which are rounded, and this apparently not from attrition. Eolian sands usually are rounded; but they are also often opaque. Some of the sands are rounded and egg-shaped and have a decidedly molten look about them, such as I have seen in volcanic glass; but this is not a universal character. Some of the Desert Sandstone has angular grains though roughly spherical in shape. Partial crystallisation has taken place amongst the grains in many instances, and this prevents the former figure from being now discernible.

The included fragments can sometimes be recognised, and if I am not mistaken, small fragments of augite, labradorite and other volcanic crystals, are amongst them. If this were beyond question it would go far towards proving a volcanic origin for the sands. Fragments of biotite, olivine, and other crystals associated usually with igneous rocks have been apparently present, but in so small a quantity and in such a fragmentary way that the evidence is not conclusive.

Finally there are the cavities in the quartz grains which seem to me after having examined many specimens, to have something peculiar and characteristic about them. Those who have not had much experience in the microscopic examination of quartzose sands can scarcely form any idea of the extent to which the grains are full of cavities. There is no such thing as solidity in this mineral; it is honeycombed to such an extent with minute bubbles, that no fragment however small is free from them. They assume the most fantastic shapes, not always rounded or oval like bubbles generally, but compressed, flattened, twisted and spread out in every conceivable form. Sometimes a succession of parallel lines of cavities in one direction is crossed at varying angles by similar lines, so as to give a clouded appearance to the grain. High magnifying powers are required for the perception of a large proportion, and each increase in the power of the objective brings into view cavities whose existence was not previously suspected. There does not seem to be much difference in this respect, between the quartz of granites, volcanic sands, and crystals that have been formed by slow infiltration without heat or pressure. At Mount Bramble near Springsure, in Queensland, there is an extinct crater on the volcanic tableland, the lava of which is covered with an infiltration of hyalite, no doubt a slow result of weathering; yet the quartz is as full of cavities as the quartz grains from the ash deposit of Mount Bromo, in Java. In the sandstone from the Victoria River, which is an aggregation of purely siliceous grains, in fact a quartzite, there is little else besides these cavities visible in the transparent particles; though even here small grains of magnetite and other minerals are present, including particles of brown augite, which are being converted into grass green mineral, probably viridite. The sands of this rock did not afford me a sufficient number of examples to enable me to speak positively; but from what I have seen I think that the volcanic cavity is more obliterated in this rock than in any other of the same character.

It is not however impossible to recognize recent volcanic particles of quartz by certain frothy aggregations of bubbles, which are unmistakably indicative not only of former melting, but boiling. Sometimes this gives rise to a ribboned structure as if the bubbles had been drawn out by flowing. There are also roughly parallel

lines twisted and undulating like the grain of woody fibre ; and finally a glass structure like Pele's-hair.*

Without entering further into the detail of the appearances presented by the sand grains when they are either granitic, metamorphic or volcanic, I may sum up by saying that it is perfectly possible to distinguish between them when they are recent, nor is the evidence entirely lost until completely changed by metamorphic action.

After having examined a considerable number of specimens of the Desert Sandstone taken from different places, I incline to the conclusion that they are all volcanic sands ; that is to say, speaking now of microscopic appearances only. The reasons for coming to this conclusion are generally the numerous inclusions of foreign matter in the quartz, their nature, and finally the peculiar character of the cavities. I do not pretend that the evidence is perfectly convincing, and I admit that the inclusions and the minerals are scanty in comparison with what I have been able to gather on recent crater walls. However, it would be difficult to reconcile the appearances in the grains of the Desert Sandstone with any other than a volcanic genesis. Moreover when we add the evidence afforded by the magnesite beds, the peculiar aggregation of these sands, and finally their unfossiliferous character, the conclusions as to their igneous origin become strengthened.

The weight of evidence becomes however, very great indeed when we notice, what I have already called attention to, that throughout Australia these sands and sandstones are always found associated with recent volcanic rocks.

It may appear somewhat unnecessary to bring so many proofs forward on a matter so obvious ; but the lithological character of these sandstones has caused them to be erroneously identified with Mesozoic strata, and even Carboniferous and Devonian. The government geologists will no doubt rectify some of these errors ; but in the mean time Mr. Clarke's map, founded alone on specimens forwarded to that gentleman, retains them. That lamented geologist gave what he considered to be the best inference in the time at his disposal. I could not record any difference of opinion between myself and this painstaking observer, who was justly considered as the father of Australian geology, without recording my sense of the difficulties under which he laboured and the immense credit due for the work he effected. Mistakes in the early history of any science are what must be expected : steps have been retraced and new systems adopted over and over again

* A filamentary variety of obsidian produced by the action of the wind upon the viscid lava projected into the air by the escape of steam from the surface of the lava lake in the crater of Kilauea, Hawaii. Pele is the name of a goddess supposed to inhabit this crater.

in geology in Europe, therefore we must not be surprised or disappointed at the same thing happening here. It is the Desert Sandstone which is being dealt with now, but it will be obvious to any one who has paid even a slight attention to the subject that this is applicable to some portions of the Hawkesbury Sandstone as well. A considerable thickness of the upper strata is composed of tufa or Tertiary ash-beds. This is especially applicable to some of the Sydney sands and sandstone and the strata on the Nepean River.

It will be remarked also that the form of these ash-deposits is nearly always crescentic with reference to the volcanic rocks, and that the thickest portion of the beds and the greatest extent is exactly in keeping with what we might expect as the effect of prevailing winds. Many instances of this can be seen on all geological maps where a survey has been made.

For those who are not familiar with volcanic phenomena it would be hard to realise that a mass of sandstone is nothing more or less than an accumulation of volcanic ashes. The word ash does not represent ashes in the ordinary acceptance of the term. We must remember what a volcano is. We speak of smoke and flame, ashes and cinders in connection with volcanic eruptions; but there is no such thing as smoke, as the word is usually understood, and no such thing as flame, unless sulphurous fumes can be called such. The smoke is steam intermingled with quantities of finely divided stone fresh from the melting cauldron, but blown into the finest particles by incessant explosion. The flame is the reflection on the clouds of steam of the incandescent molten rock rising from the depths of the earth. The ejectamenta comprise what are termed dust, ashes, sand, lapilli, pumice, and scoria, with fragments of stone; but the latter category includes them all, the difference being only that of size. The ashes therefore consist of small fragments of lava comprising minerals of the nature of felspar, augite, olivine, biotite, magnetite &c. Many of these are opaque or coloured, and traces of their crystalline form are very frequently visible. It is evident that these minerals must be abundant or scarce, or one prevailing over another according to the nature of the rock from which they are derived; but it is astonishing how one peculiar kind of mineral will prevail over a wide area.

Generally speaking ashes may be classified according to the rock formation of the volcano. Most readers are aware of the great divisions that are made between the acid or basic lavas as they are called. These fall into five great groups of rocks viz.: the rhyolites or acid lavas, the basalts or basic lavas and the intermediate lavas known as trachytes, andesites, and phonolites. The basic lavas contain a larger proportion of oxide of iron and other heavy

oxides, and hence have a higher specific gravity. They are of much darker colour, while fresh lavas of acid composition are usually nearly white. Trachyte, andesite, and phonolite ashes are of various tints of grey. But no ash keeps its colour long: the quantity of iron is too great and the minerals too unstable for the ordinary weathering not to affect them. Moisture soon produces yellow, red, and purple-brown shades. But the mineral character is not lost; and this mainly consists of silica, no matter what the chemical nature of the ejectamenta is. The acid lavas contain from 60 to 80 per cent. of silica, the basic from 45 to 55, and the intermediate from 55 to 65. Thus silica forms the great mass of the deposit, no matter under what category the lavas are placed.

I am able to give an illustration from actual experience of how these sand-beds are deposited. I happened to be on more than one occasion in the neighbourhood of volcanoes during a period of active eruption; and what I saw in connection with the deposition of ashes helped me much to understand how such formations as the Desert Sandstone have arisen.

I was in Java about the time of the eruption of Krakatoa, in 1883, and visited some portions of the kingdom of Sunda in its neighbourhood. In this case the volcano was in activity from the 20th of May casting forth ashes in great quantity. There was a kind of lull again until the 16th of June, when a fresh eruption broke out. Thenceforth there was more or less a continued scattering of ashes over a wide area. The molten mass below the earth's crust was being acted upon by pressure and gradually approaching the surface upon which the sea-water was producing a violent convulsion. Everybody knows what the result was in the catastrophe of the 27th of August. The whole kingdom of Anjer wherever I visited was covered with a coating of light grey ash, something like snow, a foot deep and more, 130 miles from the volcano. The whole of the intermediate country was covered of course in thicker deposits nearer to the volcano, except where the tidal wave had washed it away. It was incredible what destruction was caused by the ash alone. In one village trees were torn down and great limbs stripped off, as though they had been shrubs. The cocoa-nut trees were mere bare poles. The ash, though apparently so light and insignificant was really very heavy and in a very short time would accumulate in sufficient thickness to bear down even the strong resistance of the stout cocoa-nut palm. Houses were crushed in, roads were obliterated, and the sand silted up in many places so as to cover and conceal fences and hedges. At a tea plantation (Parakansala) where I was on a visit, 100 miles or so to the east of Krakatoa, at about 3,000 feet above the level of the sea, the tea plants were curiously covered over with this ash deposit, and the effect at a distance was

to resemble a flock of sheep feeding on a snow covered plain. The ash was grey, but where exposed to the bleaching effect of the sun's rays, had become white. The composition of the ash was according to Prof. Liversidge, as follows:—

	I.	II.	III.
Loss on ignition ...	2.17	2.74	2.12
Silica	63.30	65.04	68.06
Alumina	14.52	14.63	15.03
Iron sesquioxide ...	5.82	{ 4.47	.23
Iron monoxide ... }			
Manganese ... ..	.23	trace	trace
Lime	4.00	3.34	2.71
Magnesia	1.66	1.20	.81
Soda	5.14	4.23	4.25
Potash	1.43	.97	3.41
Titanic acid	1.08	...	.38
	<hr/> 99.35	<hr/> 99.44	<hr/> 100.71

No. I. by Sauer, No. II. by Renard, No. III. by K. Oebbeke. *Journ. Chem. Soc.*, 1884, p. 974.

Professor Judd dealing with the nature of the materials ejected points out that the compact lavas poured forth from Krakatoa at the close of the eruption, contained as much as 70 per cent. of silica, the dust derived from which of course would be nearly a pure sand. The lavas were porphyritic pitchstone and obsidian. The heavier lava dust, which fell in Java, and was examined by numerous geologists contained almost every variety of felspar crystals.* The minute ejecta, consisting of pumice as well as finer dust, carried by the unusual violence of the explosions into the higher atmospheric regions, where it remained suspended for very long periods, was thus drifted to enormous distances from the scene of the eruption, showing how volcanic material even from one point of ejection may be spread over immense areas. The whole of this material from the rapid rate at which it cooled, was a volcanic glass of high specific gravity and slight friability. The most characteristic substance in these dusts was rhombic pyroxene or augite.†

The above analyses show ash derived from a lava of the intermediate character and such deposits are usually grey when

* Professor Judd considers this to be without precedent amongst volcanic products. See Report of the Krakatoa Committee of the Royal Society, London, 1888.

† As an instance of the extent and distance to which this augitic dust was carried I may mention that when making a series of soundings between the Philippines and Moluccas in 1886, there was always an admixture of fresh pyroxene crystals amongst nearly every specimen of the sea bottom. On the north coast of Australia it was especially abundant.

fresh ; but after some time they become brown, as every one can see wherever sections of ash-beds are exposed, and there are few parts of the island without them. On the sides of the extinct craters the crevasses and gullies cut by the rains form gorges, which have been a subject of comment and admiration to every traveller. The precipices and escarpments in these ash-beds form a wild scenery of the grandest kind. The gorges however are in some cases cut down in the loose and friable ash for hundreds of feet and more, exposing in this way different coloured beds of black, white, brown, or yellow, according to the age of the formation. I have seen gorges of 1,000 feet deep at the very least. Perhaps the whole of this is the result of a single eruption.

As an illustration of the manner in which ash-deposits will accumulate and form mountain ranges I may take Java as an instance, about which so many erroneous impressions prevail. In a work entitled "*The Eastern Archipelago*,"* one of the popular scientific series that convey to the public the most astounding information under the name of useful knowledge, it is stated that "throughout its entire length Java is traversed by two chains of mountains, which occasionally unite, but more frequently run at some distance from each other and send spurs and branches of the most various outline down to the shore." This is an impression as prevalent as it is incorrect. There is no mountain range extending the length of the island, in fact the last hundred miles of the eastern end is formed by four craters making a rough quadrilateral. To the west of Surabaya there is an extensive mountain range which has not any extinct crater for 100 miles or more. It is deeply scored by valleys of erosion, showing that it is built up of fine ash sands in places, or by a accumulation of coarse material when the volcanic period was indeed one of nature's periods of fury. In other parts of the island too, there are detached hills of volcanic material, which have evidently never been a crater or an outflow of lava. They are accumulations of ashes which mark former eruptions, and their resemblance at times in shape and material to the Desert Sandstone is very striking. As a rule they are about 4,000 feet high, though their surface is very ragged and irregular, owing to the wearing down by rainfall which here averages nearly 100 inches per annum.

Professor Liversidge in his "*Minerals of New South Wales*,"† mentions the occurrence at New Ireland of a pale brown calcareous mudstone, looking at first sight much like a sandstone containing much volcanic ash. He also mentions a sandstone which must have had a similar origin, since the dark thin parallel planes of

* London : T. Nelson & Sons, 1880.

† London, Trübner & Co., 1888, p. 254.

stratification formed dark bands from the presence of small hornblende or augite crystals.

The following passages from Russell's Geological History of a part of North-Western Nevada,* so aptly illustrate the views taken in the foregoing pages that no apology is necessary for introducing them here. "*Pumiceous dust*.—In describing the section of upper lacustral clays observed in the Humboldt, Truckee, and Walker River cañons, strata of fine siliceous material varying in thickness from a fraction of an inch to five or six feet, were noted at a number of localities; it is now our intention to describe these abnormal deposits more fully.

"In all the exposures of this material the same characteristics were observed. The beds are composed of a white, unconsolidated, dust-like, siliceous substance, homogenous in composition, and having all the appearance of pure diatomaceous earth. When examined under the microscope however, it is found to be composed of small angular glassy flakes, of a uniform character, transparent and without colour, but sometimes traversed by elongated cavities. When examined with polarized light it is seen to be almost wholly composed of glass with scarcely a trace of crystal or foreign matter. On comparison with volcanic dust that fell in Norway in 1875, derived from an eruption in Iceland, with the dust erupted in Java in 1864 and the similar material ejected in such quantities from Krakatoa in 1883, it is found to have the same physical characteristics; but it is much more homogeneous, and, unlike the greater part of the recent dust examined, is composed of colourless instead of brown or smoky glass. In the accompanying figures, which we copy from Mr. J. S. Diller's instructive article on the volcanic sand which fell at Unalaska, October 20th 1883, the microscopic appearance of volcanic dust, from various localities and of widely different geologic age, is shown with accuracy. The peculiar concave edges and acute points of the shards of glass render it evident that they were formed by the violent explosion of the vesicles produced by the steam generated in the viscid magma from which the glass was formed, and were not produced by the mere attrition of the fragments during the process of eruption. It is noteworthy that the dust erupted from Krakatoa but yesterday is undistinguishable in its main characteristics from the material of a similar origin which fell in the waters of Lake Lahontan during the Quaternary, or from the dust thrown out by some unknown and long extinct volcano in the vicinity of the Atlantic coast, which fell near the site of Boston during pre-Carboniferous or possibly in pre-Cambrian time. The volcanic phenomena of to-day are governed by the same laws as obtained

* U.S. Geological Survey.—Monographs, xi., p. 146, Washington, 1885.

at the dawn of geologic history. . . . More extended operations in the field revealed that beds like those described above are not confined to the Lahontan basin, but are found as superficial deposits above the Lahontan beach at many localities and at points far distant from the old lake margins. Accumulations of the same nature occur in the Mono Lake basin, interstratified with lacustral deposits, and were also found in the cañons about Bodie at a considerable elevation above the level of the Quaternary lake that formerly occupied Mono Valley. About Mono Lake these deposits are frequently of a coarser texture than those found farther northward, and, at times graduate into strata which reveal to the eye the fact that they are composed of angular flakes of obsidian.

"The Mono Craters form a range of some 10 or 12 miles long, which extends south-eastward from the southern shore of Mono Lake, and in two instances attains an elevation of nearly 3,000 feet above the lake. A few coulées of dense black obsidian have flowed from them, but the great mass of the cones is formed of the pumiceous obsidian which occurs both as lava-flows and ejected fragments, the latter forming a light lapilli which gives a soft grey colour to the outer slopes of the craters. Fragmental material of the same nature has been widely scattered over the mountains and on the ancient moraines that occur in the Mono Lake basin, while fine dust, unquestionably derived from the same source may be traced to a still greater distance.

"From the evidence given above we conclude that the strata of fine siliceous dust-like material occurring in the Lahontan sections, as well as the similar beds found about Mono Lake and scattered as superficial deposits over the neighbouring mountains, are all accumulations of volcanic dust which was probably erupted from the Mono Craters. The greatest distance from the supposed place of eruption at which these deposits have been observed is about 200 miles."*

In the same region we have ash deposits like those of Sydney, taking the form of loose sand dunes which the author thus describes: "The first acquaintance the explorer in the Great Basin usually makes with the material forming these deposits is when it is in motion, and fills the air with clouds of dust, sand, and gravel, which are blinding and irritating, especially on account of the

* I have to observe, with reference to this quotation, that the description here given of the volcanic dust from Krakatoa does not quite tally with the specimens gathered by me. These were not wholly composed of glass, and, small as they were, they were full of traces of crystal and foreign matter, especially microliths of triclinic felspar and pyroxene. I am not however contending that the Desert Sandstone is composed of volcanic dust, but volcanic sand derived from ashes with which of course dust is intermingled.

alkaline particles which saturate the atmosphere at such times. Dust-storms are common on the deserts during the arid season, and impart to the atmosphere a peculiar haziness that lasts for days and perhaps weeks after the storms have subsided. Whirlwinds supply a characteristic feature in the atmospheric phenomena of the Far West especially during calm weather, and frequently form dust columns of two or three thousand feet, even more in height, which may many times be seen moving here and there over the valleys. The loose material thus swept about at the caprice of the winds tends to accumulate on certain areas, and forms dunes or drifts which at times cover many square miles of surface. During its journey across the country the material which finds a resting place in the dunes becomes assorted with reference to size and weight, so that the resulting sand drifts are usually homogeneous in their composition, but are characterised by extreme irregularity of structure when seen in section. In the Lahontan basin the sub-aërial deposits are usually composed of fine sharp quartz sand; but in some instances small drifts are principally formed of the cases of ostracoid crustaceans."

Without following the author into all the details, some further peculiarities of these eolian sands may be inserted here. A few miles further north there is a belt of drifting sand about 40 miles long by 10 wide. The drifts are fully 75 feet thick and the whole vast field of sand is slowly travelling eastward. The sand is of a light creamy-yellow colour and forms beautifully curved ridges and waves. Another area is south of the Carson desert. This train of sand dunes is 20 miles long and four or five wide. In a sheltered recess of Alkali Valley the sand drifted by eddying wind currents has formed a mountain 200 to 300 feet above the plain. This great sand hill changes its outline from year to year while the winds modify the rounded domes and gracefully curving crests of creamy yellow sand. This tract is also slowly travelling eastward across mountains and deserts, unaffected by the topography of the country. The sands find temporary resting places on the terraces in the black basalt on the shores of Lake Lahontan, "bringing out the horizontal lines in strong relief and accentuating the minor sculpturing of the cliffs." (op. cit. p. 155.)

I have given this quotation rather fully, to show how the volcanic character of these sands does not prevent them from being, in particular cases, eolian. In my former paper on the Hawkesbury Sandstone I laid stress upon this mode of formation, but as a rule the ash sands do not always remain loose and drifting. Probably their consolidation depended upon the amount of water that was discharged from the volcano which sent them forth.

The colour of the volcanic sands is another thing to which attention may be drawn. The creamy yellow sands around Sydney

will suggest comparisons with those of America. When consolidated and affected by oxidation the sands become brown and red with bands of limonite.

It is nothing new in geology to identify an extensive rock formation with ash deposits. The ancient city of Rome itself affords an apt illustration of this, which bears so high an interest from its scientific and its antiquarian character that it is well worth the space it will occupy by a reference to it. Everybody has heard of the Seven Hills of Rome, on which the city is seated at the eastern side of the valley of the Tiber. Four of the hills namely the Quirinal, Viminal, Caelian, and Aventine belong to the rising ground or plateau forming the valley. Two of them, the Palatine and Capitoline are detached. The Palatine, 170 feet high, appears to have had precipitous edges. The Capitoline, though only 150 to 160 feet in height, is from its abrupt face and well-marked outline, a conspicuous instance of a relic of ash-beds spared from the weathering of rain and rivers. For the rising ground on the eastern side, an elevated flat which reaches its culminating point in the Esquiline, 218 feet above the river, is composed of volcanic ashes once spread in a continuous sheet all along the valley. The ashes are now consolidated into a volcanic sandstone or tufa, hard enough to be used as building stone, but also easily excavated into the extensive subterranean cemeteries of the Catacombs. This great deposit of ashes came from some recent craters at no great distance from the city. Seventeen miles or so on the north-west are the Ciminian Hills, with Lake Bracciano, an enormous crater, now filled with water instead of fire. Thirteen miles to the south-east are the Alban Hills, with the relics of another extinct crater at Lake Albano. The Janiculum Hill which is on the west side of the Tiber has but little ash on its north side, but is composed of marine beds with shells such as now exist in the Mediterranean, though many are extinct. On the flanks of the Aventine Hill there is a still later deposit of freshwater travertin or recent limestone, showing that the river reached 140 feet higher than it does at present, before the ash-beds were cut down, and the Mistress of the World had spread herself out on the sides of the valley. She played her part and innumerable ruins tell of her former splendours. But the ash-beds lie beneath all, telling of a phase in her history such as once was shared by Australia.

It may be mentioned also as an illustration of these ash accumulations, that I saw the result of a very recent eruption at the volcano of Taal, near Manila in the Philippines. I descended into the crater in March, 1885, when all was quiet; but returning in 1886 I found a singular scene of devastation. An eruption had commenced in the preceding September, and the fall of ashes

and liquid mud had caused widespread destruction for leagues around. The crater, it may be mentioned, is on an island which was at the time of my first visit partly covered with vegetation. But after the eruption, all this was devastated, and the forest entirely burnt and destroyed. For this I must refer readers to my account of the Volcano of Taal in the Proceedings of the Linnean Society of New South Wales, Vol. ii., (2nd series) 1887, p. 685.

The whole of the country round Manila for many leagues is covered with a fine-grained deposit somewhat different in mineral character from that of Rome, but evidently a volcanic sandstone or tufa derived from ash. Of this the buildings and walls of the city are constructed, for it forms a moderately compact sandstone like that of Rome. It is very much altered in places both in colour and its state of oxidation, yet a good many of the thickest beds have accumulated since the Spaniards conquered the islands, or about 320 years. Not many reliable records of the eruptions have been kept; but leaves of plants are found in the strata which are not indigenous, but beyond a doubt had been introduced by Europeans.

When we are dealing with a completely extinct volcanic region as in Australia, it is of course impossible to make a general surmise as to the periods covered by such eruptions as those which spread the Desert Sandstone over so much of the north and the interior of Australia. They may have been not only lengthened, but also separated by long intervals of rest; quite sufficient for the surface to have become loosely blown about by the winds, and giving rise to those round-grained sandstones found in the Mary River. The little change that has been effected in active volcanoes during the historic epoch, makes one think that what we call the volcanic part of our Tertiary era, represents a long duration of time. But in any case we might expect great deposits of ash ejectamenta of which the Desert Sandstone represents but a portion. I may mention in conclusion that whatever differences there may be between the sandstones of say Manila or Java and Australia when they are long exposed to weathering influences, there are always traces of a good deal besides pure siliceous sands. As a rule, recent volcanic sands and ashes are darkened by masses of small opaque fragments of black scorïæ, sometimes magnetite, pumice and what may be black fragments of dolerite. The abundance of these cindery opaque particles in recent volcanic ash is very striking, giving it a black igneous appearance which is unmistakable. Such appearances do not certainly belong to the Desert Sandstone, but there are traces of it. At any rate the differences in the appearances presented by the sands of recent volcanoes and that of the Desert Sandstone can be accounted for by chemical metamorphism from weathering, to which the latter has been exposed.

I have taken it for granted here that the Desert Sandstone in North Australia is of Tertiary age. This assumption depends upon the fact of its strong resemblance to a similar formation in Queensland which rests upon Cretaceous rocks. It is worth while however, to warn observers that the nature of such formations, that is simple sandstones without fossils, is to resemble each other as closely as possible, no matter to what age they belong. It is quite possible that sandstones of the middle or lower Mesozoic might be mistaken for those of Queensland, and therefore I do not assert positively that those we have been treating of are Tertiary, much less to claim for them any place in the Tertiary system. Yet it must be added that the recent character of the basalts and dolerites cannot be doubted, and all geologists have regarded them as Pliocene. The Mesozoic volcanic products on the other hand are diorites or greenstones of very uniform character throughout Australia and Tasmania.

It is unnecessary to describe all the localities where I have collected sands as I have given details of the microscopic appearances presented. It has already been stated that the volcanic rocks form more or less a ring round the northern, eastern, and part of the southern sides of the Australian continent. My observations have convinced me that the volcanic period has altered the physical features of the eastern side of the continent in a remarkable manner. Wherever recent lavas occur they now form the watershed between the rivers flowing into the Pacific Ocean and those flowing westward into the interior. Before this volcanic period the Divide on the eastern side was mostly granitic, and even now forms a much higher portion of the mountain range. The trap-rocks always give rise to rivers, some of which are amongst the most important on the north and east coast, such as the Flinders, the Victoria, the Leichhardt, the Roper, the Daly, the Mitchell, &c., &c. There arises also another set of rivers of smaller dimensions having their sources in the springs at the edge of the Desert Sandstone.

It can be proved however, that there has been formerly a very gradual slope from the ocean towards the centre of the continent, and that what is called the plateau is a local accumulation of limited extent. Yet some of the extinct craters are so far inland that it would be hard to restrict the boundaries of the ash and lava strata. They may be found in patches right through the continent. To suppose that they once occupied a very much larger area, or covered the whole country seems from the nature of the case to be an exaggerated view. Volcanic sands may have been carried to great distances, but until observation has shown that they covered the whole continent, we are hardly justified in supposing it. The frequent recurrence of the sandstones in widely separated

regions, especially when their origin was unknown has naturally suggested one immense formation.

Fluviatile Conglomerates.—These consist of a coarse, slightly reddish, excessively hard quartzite, with numerous fine blackish lines of specular iron. They enclose many rounded waterworn quartz pebbles of various colours, sizes, and shapes, but all smoothed by fluviatile action. These pebbles are white for the most part, and generally sparingly scattered through the strata; but there are sometimes thick beds of conglomerate with fragments of slate and numerous veins of segregated quartz of small size. There are two kinds of stratification, namely, large divisional lines from one foot to six feet and more apart, and cross stratification or false bedding. Two peculiarities of this formation will now be mentioned:—1. The curious dip of the beds. 2. Its broken and fragmentary character.

1. The formation dips away to the east along the existing streams at an angle of about 30 degrees; that is to say the large partings of the beds seem to have this dip; but in this matter I much regret that I had not an opportunity of making more extensive observations, because sometimes I was inclined to think that the beds have been truly upheaved to a high angle independent of the false bedding or cross stratification. In other instances there was not the same evidence of tilting.

Mount Douglas will afford an illustration of what I am describing. It is a conspicuous hill lying to the eastward of the telegraph line about 100 miles south of Port Darwin. It forms the extreme end of ranges of meridional hills of a very broken character, though not exceeding 500 feet in height. Mount Douglas itself is a castellated hill, quite abrupt on its south-western end, and showing in section about 400 or 500 feet of the fluviatile conglomerates I am now describing. The strata dip away from the river McKinlay at an angle of 30 degrees or more; and though the general appearance would lead one to believe that this dip is due to a tilting of the beds, a more careful examination induces me to think that this angle may represent the direction of the current wherein the conglomerates were formed. There is nothing in the neighbourhood to correspond with this inclination of the beds, which are certainly the newest and uppermost rocks to be seen hereabouts. At the Margaret River I noticed the same dip of a similar conglomerate with similar appearances to those met with at Mount Douglas, though the direction of the dip was different. At Kekwick's Springs, on the tableland beyond the head of the Mary, an outcrop of the same kind of conglomerate was observed with the same high inclination in the general dip of the beds. This outcrop was very small and there was no detached tableland near it. At the head of the Katherine River about 12

miles north-east of the telegraph station, the river flows through a narrow gorge of sandstone conglomerate, which, in the few places that I was able to examine, dipped away from the stream in the manner described in the other localities. On the summit of all these sandstone tablelands the strata seemed to be horizontal ; but this was difficult to ascertain satisfactorily owing to the amount of false bedding. I noticed the same curious dip in the McAdam Range on the side of the Victoria River and the same has been referred to by Gregory, Wickham and Stokes ; but I was not able to examine the locality closely. We were but three Europeans in a small steam launch, and the blacks are particularly numerous and hostile, so that to land anywhere was to risk unnecessarily a personal encounter.

This then is the character of the fluviatile sandstones and it is an unvarying one wherever I have met the formation. The uniform dip, the hard flaggy nature of the deposit, and the included waterworn conglomerate mark it unmistakably. I have never met with it far from any river, but it is not always present. On the Victoria River it is never absent ; but sometimes the range or plateau recedes five or six miles away from the channel as in the case of the McAdam Range. On the Katherine River there are long stretches of country in which it flows through a uniform sandy valley, and then succeeds another kind of channel which is bounded by broken tablelands of this fluviatile sandstone, either abutting on the stream or enclosed in valleys five or six miles in width. The broken detached character of these plateaux gives rise to a perfectly impassable country, with rugged rocky scenery of grand and wild character. In all cases the stone is composed in the same manner as already described with the usual waterworn conglomerate.

Now are we to attribute this singular formation to trap-rocks and ash, or what is its nature ? The difference from the Desert Sandstone is the perfectly smooth and rounded conglomerate which it contains, and more or less through the whole of it ; that is waterworn quartz gravel or a conglomerate of boulders eight or ten inches in diameter. The quartz is usually, but not always, milk-white. It is certain that we have here evidence of the long sustained action of running water rubbing down the very hardest materials and perfectly rounding them. Moreover the quartz does not belong to the sandstone formation, but rather to the palæozoic slates upon which it lies.

On the whole the most probable interpretation of this formation is that the conglomerate has been derived from a river channel through the palæozoic rocks which contain an abundance of quartz reefs. The sand has been an ash deposit partly filling up the channel and mingling with the conglomerate or covering it over.

At the Yam Creek section, I would remind readers that there is ten feet of large waterworn conglomerate, without any of the characteristic sand. This has been clearly derived from the granite before there was any admixture of other material. Generally speaking the conglomerate increases towards the base of the formation to the exclusion of the sandstone.

But the curious fact observed in connection with these fluvial deposits is their great disproportion to the streams now connected with them. At Yam Creek the valley is a mile and more in width and the present small trickling stream is 90 feet below the bed of conglomerate. Its waters increased tenfold would be utterly inadequate to produce the erosion of 90 feet through granite and a valley of such width. The same argument may be used towards all the rivers in North Australia; they seem so much smaller than the deposits connected with them and the erosion effected that one is forced to the conclusion that the rivers, though strangely enough occupying the same valleys, have become reduced in an extraordinary manner compared to what they were formerly.

The erosion here referred to is different in its effects in the different streams. Thus the valley of the Victoria River is bordered on its whole course as far as I have seen by the fluvial conglomerate into which the waters of the stream are daily making inroads. In the Daly River the same thing is taking place. In the Katherine River which is the main branch of the upper Daly, the river, as I have said, flows in some places through a wide and rugged tract of sandstone conglomerate; through other tracts in a deep sandy valley; and again, on the north side of a wide plain and at the foot of a very gradual slope of Desert Sandstone. From these considerations I think that the fluvial sandstones are never more than local deposits of limited extent. If the sandstone once covered the whole of the country as Mr. Daintree supposes, these rivers would cut through valleys of the formation. Instead of this we have constant instances of the stream on one side winding round a sandy slope, which is evidently the thinning out of the deposit, while on the other side there is a wide plain of the older formations without any evidence of their having formerly been covered with an ash deposit.

There is no very great difference between the conglomerates connected with the fluvial sandstone and what are called the "drifts" of Victoria and other colonies. Mr. Selwyn divides these into two formations, the newer drifts, and those which he considers upper and middle gravels, boulders, and water-worn conglomerates. The first are Pliocene or what Mr. Selwyn considered to be Pliocene, and are auriferous; the second he calls Miocene, and have never been found to contain gold. In some instances the oldest auriferous formation is made up of successive

layers of volcanic and sedimentary material that gradually fill up the old valleys. The older waterworn gravels have been met with in the several localities from sea-level to an elevation of 4,000 feet; but some of these may not have owed their origin to fluvial action. Hardly any other mode of accumulation will satisfy the requirements of the drifts of North Australia.

It is very singular that we should find such constant and unvarying evidence of the greater height at which the rivers flowed, when we should be led to expect immense subsidences in the volcanic tract. After such outpourings of lava and such an enormous transfer of material to the surface in the form of ash, one would expect to meet the same evidences of subsidence which we find in all volcanic regions. There is certainly no evidence whatever of any upheaval. Possibly it may be explained by supposing that the most of the river valleys were filled up in part by the volcanic ash deposit, until gradually the rivers cut down the loose material to its former level.

It seems to me probable that the continent, before the volcanic period, was higher above the sea than it is now. The period itself may have been connected with the destruction of the ancient land fauna of Australia, which does not apparently overlap the existing fauna, at least as far as the terrestrial mammalia are concerned. In Queensland the evidence about the Darling Downs and main range is that violent and sustained volcanic disturbance was followed by floods which swept into heaps fragments of the remains which volcanic action had destroyed. The deposit at King's Creek is an extremely abundant collection of broken bones, mingled together with indescribable confusion, on a few square yards of ground. In this there are gigantic marsupials—kangaroos, wombats, and opossums, with water-birds, large crocodiles, gigantic lizards and turtles.

With regard to the age of some of the later volcanic phenomena, we have very clear evidence in Moreton Bay that it belongs to the most recent period. There is satisfactory evidence afforded in a lava or ash stream which runs into the sea at Cleveland. It has flowed over shells and corals which differ in no way from the existing marine fauna. There is a basaltic flow at Lytton a few miles further inland which appears as old as most of the volcanic formations of the higher table-lands. The Glasshouse Mountains on the north side of the bay, of which figures are here given (see plates xix. and xx.) are apparently no older.

The volcanic emanations of Mount Gambier, Mount Shanck, and Tower Hill belong also to the recent period, and are connected with the existing fauna.

Altogether the evidence afforded by the volcanic rocks throughout Australia is that there were at least two distinct periods of

eruption. The first or oldest, extends nearly all round the continent, and at least 300 miles into the interior. The south-west part of the Australian land seems to have escaped this volcanic disturbance, which however extended to Tasmania. There is a second period commencing towards the Pliocene epoch, continued into the most recent post-Pliocene times. These conclusions are entirely in accordance with those arrived at by Mr. Selwyn and his officers in the Victorian geological survey. They are also fully confirmed by Messrs. Daintree and Jack's observations in Queensland.

Mr. Selwyn's observations are thus stated *:—"The mineral and lithological characters of the volcanic products of the two periods present marked similarities and differences. An irregular concentric concretionary, or polygonal jointed structure, is eminently characteristic of the older, so much so that, though it affords any quantity of excellent road-making or railway-ballasting material, no building-stone is ever procured from it. The columnar structure is also not uncommon in both the older and the newer formations. Interbedded with the harder layers are strata of a very soft, unctuous, amygdaloidal clay or 'wacke,' bluish-grey, brown, yellow, brick-red, or pure white. Sometimes the section exposed consists almost wholly of such clay, traversed by ferruginous veins, and enclosing hard lumps or balls of dense-black basalt." The solid layers are mostly a dense, dark, crystalline basalt, composed chiefly of augite, labradorite, olivine and specular iron. Though some are cellular they are far more solid and dense than the recent Pliocene lavas, which present a much greater variety of texture, the most common and characteristic being the well-known Melbourne bluestone. It is a true dolerite or variable mixture of augite, labradorite, iron and carbonate of lime, vesicular and coarsely crystalline and compact, and not unlike a hard calcareous or metamorphic sandstone of blue, grey, or almost black colour. Olivine, specular iron, and hyalite are associated but not as component parts of the stone. In some districts it is associated with beds of regularly stratified ashes. These are so soft when first quarried as to be easily sawn into blocks which harden considerably after exposure. Obsidian is found, but no true trachyte.

The analysis of the older basalts shows a considerable proportion of iron and magnesia, the iron being as high as 31 per cent. in some lavas, and the magnesia 18. In the newer volcanic basalts a similar character is prevalent in some of the dolerites.

Mr. Daintree says in the essay on the geology of Queensland, from which we have already quoted, that "volcanic action seems

* Notes on the Physical Geography, Geology, and Mineralogy of Victoria, p. 29, by A. Selwyn, &c., Melbourne, 1866.

to have played the most important part in determining the elevation and present physical outline of north-eastern Australia. The main outbursts of lava have taken place along the dividing range, and these are generally due to the Pliocene disturbance. "The southern areas namely, Peak and Darling Downs &c. are older agreeing with the Lower Volcanic of Victoria."

The rock masses of both periods are basic in character and may with rare exceptions be all grouped as dolerites. Mr. Allport says: "This dolerite contains triclinic felspar, augite, magnetite, pseudomorphs after olivine. The felspar prisms are clear and transparent and exhibit well the striæ and bands of colour when examined in polarized light. The augite occurs in small brown crystals and grains; it frequently contains black magnetite and is sometimes slightly altered. The olivine has been completely altered to iron oxide, and appears in the sections as bright red grains and crystals. Pseudomorphs of quite similar character occur in the dolerites and basalts of the coast of Antrim."

Mr. Daintree speaks of an interstratified bed in the Upper Volcanic of a *highly siliceous rock in which one half the mass was composed of quartz crystals arranged in a quartzose matrix.*

In two places the Desert Sandstone is seen resting on the older Volcanic, namely at Agate Creek, a tributary of the Gilbert River, and near Morinish station.

These two volcanic periods formed a time when a fire-belt fissure undoubtedly existed round nearly the whole of the continent of Australia. On the south side there has been elevation of the land to the extent of 600 feet, about the period of volcanic activity. There are no such signs of elevation in any other part of the continent; no Tertiary marine fossils are found except on the south side. The volcanic evidences are not confined to the mainland: a few island craters exist at some short distance from the coast-line; such as Mount Prudhon, and probably several other islets between Keppel Bay and Whitsunday Passage. There are also flat-topped islands of Desert Sandstone amongst the numerous groups in the same locality. Altogether the evidence on East Australia is in favour of subsidence. On North Australia the shallow sea and other evidence would seem to indicate a stationary period. I do not speculate further on the geological history of those times, for the absence of facts would make such guess-work practically useless. The elevation of the Great Australian Bight is, however, a fact we can point to with certainty that it must considerably have altered the outline of the continent. This with the volcanic period and the formation of the Desert Sandstone are grand events in the physical history of our continent, succeeding the great Cretaceous sea which once invaded the north-eastern part. The fire-belt fissure seems to have been an isolated

outburst on the earth's surface of very long ago, and perhaps the great oriental fissure which extends from Sumatra to the Philippines is its substitute. Had it not been for this fiery epoch all Australia would be utterly barren and fruitless, so we owe to its energy something more than the stony arid plateaux of Desert Sandstone.

Microscopic Appearance of Sands.—I now proceed to give the result of microscopic examination of the sand grains showing how far they afford evidence of their volcanic character.

Sandstone from Mary River, North Australia.—Grains all perfectly transparent, with no opaque particles, but in shape singularly rounded; all the rugged angles smoothed off; most of the particles spherical and some completely egg-shaped. Foreign inclusions not many; sometimes stained by oxidation a brownish-red (pseudomorphs after olivine?) more rarely grass-green (viridite?) Cavities not numerous, but sometimes arranged thickly in lines of trichites or rows of bubbles. Polariscope—about one-fifth of the grains are dark, with crossed nicols. The rest polarize brilliantly, rarely showing mineral inclusions of felspar. The number of glassy particles in this sand with occasional crystals of hornblende and other minerals, certainly suggest a volcanic origin. The rounded outline is due more probably to melting than attrition.

Port Darwin Jail Road.—Grains angular, none rounded, mostly transparent, but a few opaque, all more or less reddened by oxidation. Foreign inclusions somewhat numerous, cavities very numerous; sometimes taking the form of lines of trichites. Polariscope—about a third glassy, refusing to polarize or only feebly, the rest brilliantly, with the characteristic appearances of chrysolite, augite and felspar crystals broken and fragmentary. The large proportion of volcanic glass and included microliths give it certainly a volcanic appearance.

Fanny Bay, Beach Sand.—This sand is largely intermixed with marine remains, notably foraminifera (*Quinqueloculina*, *Rotalia*, *Planorbulina*, *Globigerina*, *Textularia*, &c.) echini spines, fragments of shells, corals, bryozoa, *Gorgonia* spicules and the usual tropical marine exuviae, with opaque granules of magnetite, ferric oxides and a few crystals of chrysolite, transparent grains of quartz with included cavities and microliths. Polariscope—the few grains of quartz polarize freely and show inclusions of felspar, augite, chrysolite, and other volcanic minerals, all more or less changed. Some perfectly formed crystals of chrysolite and few glassy fragments. The matrix of volcanic minerals with marine exuviae is very marked in this sand, but probably some of these may have drifted from the active craters of the Moluccas and the islands to the northward. The transparent sand-grains though few in number are somewhat like those of the Mary River.

It is not necessary to add further details about the microscopic character of grains of sand derived from the Desert Sandstone in other different places, since they are all of the most uniform character, showing few opaque particles, a fair proportion of volcanic glass, very transparent quartz grains with foreign inclusions principally of chrysolite, but often with small fragments of augite partly converted into hornblende, various kinds of feldspars and gas-cavities.

For comparison, I insert a few notes on volcanic sands and ashes.

Ash from Krakatoa.—This ash, aggregated into small rounded grains like sago, caused by moisture of some kind, possibly the steam connected with the volcano. Particles when spread out very finely divided and more than half quite transparent, the included fragments of magnetite and other spherulites very numerous; also gas cavities; some of the grains having the appearance of glassy froth of minute bubbles, in others the cavities forming rough parallel lines like the irregular grain of woody fibre; glassy fragments with the cavities drawn out into a long ribboned structure with occasionally aggregated crystals of augite, biotite, chrysolite, and labradorite. About half the fragments do not polarize.

Taal Volcano, Luzon, Philippines.—Most of the larger particles opaque, quartz and feldspar whitish and transparent, full of brown and black spherulites of magnetite and other minerals; gas cavities not so numerous as the included minerals, but all very much mingled as if frothy. Polariscopes—only a very few fragments polarize belonging to the finest dust, the glassy particles however are frequently opaque.

Sand Sea, Bromo, Java.—More than half the particles opaque, transparent particles polarizing brilliantly with few exceptions, some of the fragments showing crystals of labradorite and other feldspars besides olivine and augite. Cavities and spherulites numerous, making most of the transparent grains frothy looking. Some of the opaque grains with crystalline faces. The actual crater of Bromo is a hill composed of the finest possible dust which is incessantly discharged with a loud series of explosions. These follow each other so closely as to make a roaring noise, that can be heard from a long distance. The dust thus discharged is a brownish powder, about half the particles of which are glassy and refuse to polarize. There are a few dark, opaque granules, the rest being transparent with comparatively few included microliths. Augite, olivine, and twin feldspar crystals and microliths of feldspar very numerous.

As a rule, it may be generally stated that the volcanic sands are darker and contain a very much larger proportion of opaque fragments than the grains of the Desert Sandstone. In polarizing

also the fragments of crystals are much more numerous and unmistakable. There is much more volcanic glass, and the gas cavities have a decidedly more frothy look. Microscopic investigation shows decided differences between the sands of the Desert Sandstone and fresh volcanic sands; but these differences are such as can be accounted for by metamorphic action or local peculiarities, and the resemblances are such as to show the probability of a common origin. Moreover the discharge of pure creamy yellow sands as ashes from certain volcanoes is an undoubted fact of experience.

Conclusion.—The following conclusions are the result of the present inquiry into the nature of the Desert Sandstone:

1. What is regarded as belonging to this formation is found in detached plateaux through all tropical Australia.

2. It is characterised on its upper surface by magnesites, but the great mass of the formation is sandstone of a red, white, yellow, or brown colour.

3. Fluvatile sandstones are found near all the rivers, and only near them. They are distinguished by waterworn quartz pebbles and boulders which gradually increase towards the base into a waterworn conglomerate.

4. The fluvatile sandstones dip at an angle of thirty degrees throughout Arnhem's Land and along the Victoria River.

5. These sandstones are of a very broken character, rendering the country in places absolutely impassable. This is especially the case on the upper portion of the Daly or Katherine River.

6. The whole of these formations, except the conglomerate are probably derived from volcanic ashes. A microscopic examination of the sand grains would seem to bear out this conclusion.

7. The geological age of these sandstones is uncertain, but probably belongs to the two great volcanic periods of Tertiary age, the latter of which extends into the existing period. The lowest beds lie upon the Cretaceous formation.

8. The old idea of the broken edge of a great continental plateau is due to this formation, which, however, exists only in patches.

9. The surface of the Desert Sandstone is not entirely sterile, as it supports a poor vegetation of eucalypts, porcupine and coarse grasses; but as a rule the country is of a worthless character.

Specific gravity of Desert Sandstone.—The following table of the specific gravity of specimens of sandstone collected by me was kindly made at my request by Prof. A. Liversidge, F.R.S., using Joly's spring balance.

1. Red sandstone, base of Desert Sandstone, Gorge and Yam Creek, 2.60.

2. Sandstone, Victoria River, 2.51.

3. Desert Sandstone, Adelaide River, 2·59.
 4. Gorge of the Katherine, 2·54.
 5. Coarse friable sandstone from head of Mary River, North Australia, and under 40 feet of magnesite, 2·57.
 6. Desert Sandstone, McMinn's Bluff, 2·51.
 7. Desert Sandstone, McMinn's Bluff, 2·36 – 2·37.
 8. Limestone, Tableland, Katherine River, 2·69.
- The specific gravity of the magnesite was about 2·90, but at present I have no specimen to confirm this.

EXPLANATION OF PLATES.

Plate xix., fig. 1.—Prismatic basalt, Glasshouse Mountain, Moreton Bay, Queensland.

Plate xx., fig. 2.—Core of prismatic basalt, Glasshouse Mountain, Queensland.

Plate xxi., fig. 3.—Various specimens of volcanic dust.

Plate xxii., fig. 4.—Desert Sandstone, Mary River, North Australia, $\times 70$ diam.

Plate xxii., fig. 5.—Ash from Bromo crater, Java, (active volcano) $\times 70$ diam.

Plate xxii., fig. 6.—Sahara Desert Sand $\times 300$ diam.

Plate xxiii., fig. 7.—Hyalite from lava, Mount Bramble, Springsure, Queensland.

Plate xxiii., fig. 8.—Desert Sandstone, Yam Creek, North Australia, $\times 50$ diam.

ON A NEW SELF-RECORDING THERMOMETER.

By H. C. RUSSELL, B.A., F.R.S., &c.

[One Diagram.]

[*Read before the Royal Society, N.S.W., 7 November, 1888.*]

I NEED not remind the members of the Royal Society that the attempts to make a really satisfactory recording thermometer have been very numerous, and that it is probable that a complete solution of the difficulty in recording changes of temperature accurately has yet to be discovered; but I think I shall be able to shew you that the one I have to describe this evening is in many respects an advance upon those which have gone before it.

What is required is an instrument which will accurately record every change of temperature, and at first sight it seems that the photographic method gives all that is desired. In this the rise and fall of the mercury cuts off or increases the light which is arranged to pass through the tube and fall upon a piece of sensitive paper. The instrument works beautifully, but is subject to the following objections: in order to get a column of mercury large enough, the bulb has to be of considerable size, and therefore simply from its mass cannot change its temperature as quickly as it ought to do, and then the line of light which passes its tube falls on the paper which is moving slowly forward, so that slight oscillations overlap upon the paper and are thus obliterated. For instance, suppose there is a change of half a degree in one minute of time, the line of light covers more space than the paper moves in a minute, so that although the mercury has risen and cut off the light from a part of the paper equal to half a degree in height, the clock has not moved it on fast enough to bring a new part of the paper under the new condition wholly, but the part presented to the light at the end of the minute is nearly the same as it was at the beginning, and hence the light acts upon it, and in these two ways all the sudden changes of temperature get lost. To a great extent this must always be so when glass thermometers are used, because if large enough to record they take some time to shew changes of temperature, as every one knows who has had anything to do with them.

The plan I have adopted, I have had at work for some weeks in a very rough model, which I have brought here to shew you, as I think it is quite new. It was suggested to me as an application of a principle of recording small changes, which I recently brought before another scientific society as a means of recording changes in the "*direction of the vertical*," and it may be briefly described as the method of electric contact. This method affords a means of testing minute changes of position with surprising accuracy; one thousandth part of an inch is a small quantity, and a tenth of that is a quantity that few processes in in the arts will deal with; but the method I am using will detect with certainty, even in this rough model, one-third of that small quantity, or $\frac{1}{3000}$ part of an inch, and will, I am sure, when properly made detect $\frac{1}{10000}$ part of an inch of change.

In the model you will observe that I have a cylinder 26 inches long and 10 inches in circumference, (see diagram) and that over this an electrical pen is worked gradually along as the cylinder turns, it traverses 24 inches in the day or 1 inch per hour; fixed to the end of the cylinder as you see, is a wheel with teeth only half way round it, along side of this is a very carefully made screw with 50 threads to the inch, and on this screw a wheel with as many teeth

as there are in the half wheel on the cylinder end. As the cylinder turns; its half-wheel gears into the wheel on the screw and turns the screw one turn, at the same time winding up a weight which will turn the screw back directly the half wheel gets out of gear. Now the nut of the screw is so arranged that when the screw is turning, this nut is pushed forward $\frac{1}{10}$ of an inch = one turn of the screw, and it comes back suddenly as the weight falls. We have then a regular motion forward and sudden retreat every minute, *i.e.*, every turn of the cylinder, so much for the recording parts. The thermometer is a piece of thin zinc tube $\frac{3}{8}$ inch in diameter and 20 inches long, it is held firmly in a brass clamp at the end most distant from the recording parts, and from its free end projects a pin which is held forward by a spring, and is pushed back when the motion of the screw forces the nut against it; the needle is tipped with gold, and the part of the nut which comes against it is also tipped with gold, to ensure good electrical contacts. A battery connected with these parts, and the electrical pen, complete our requirements, and then the clock being set in motion events follow in this order. The cylinder turns slowly under the pen, the wheel on its end gears into the wheel on the screw, which pushes the nut forward, and the instant it touches the pin in the end of the zinc, the electric current brings the pen down on the paper and a record of the exact spot is made; at each revolution this is repeated and results in plotting out the temperature curve with surprising accuracy. I have watched the working a great deal, and find that a change of $\frac{1}{10}$ of a degree in a delicate standard thermometer is shewn also by a change in the length of this piece of zinc tube, and appears distinctly on the cylinder, being represented by $\frac{1}{100}$ of an inch of paper. Close observation has shewn that the zinc tube is more sensitive to changes of temperature than the delicate standard thermometer which I keep along side of it.

You will observe that I have mounted the zinc tube on glass, because the really effective change is *only the difference between the expansion of zinc and glass*, the expansion of the glass tends to push the end of the zinc tube away from the screw, while that of the zinc brings them nearer together.

If we take the expansion of zinc as .0000173, and that of glass as .0000046 we find the effective expansion is .0000127 for one degree, and therefore .00000127 for $\frac{1}{10}$ of one degree, this on 20 inches amounts to 0.000025 or $\frac{1}{40000}$ part of an inch, and if as I have shewn, this extreme delicacy can be got from a rough working model, I have no doubt whatever that when properly made the apparatus will record changes of only $\frac{1}{100000}$ part of an inch.

This is not the time or place to point out the numerous possible applications of the principle involved in this instrument to the

requirements of the ordinary arts, in which there are many processes which require this extreme accuracy of measurement if it can be applied automatically at a moderate cost, and this can readily be done. I may state however that this application of the method of electric contacts *confirms* the view founded upon some early experiments, which I expressed two months since, viz., that it will be possible in this way to record with certainty changes in the direction of the vertical of $\frac{1}{10}$ of a second of arc, and to plot these out on a cylinder shewing the amount of such changes, and their direction, as a check upon the transit instrument, and it may be interesting to add that a change of $\frac{1}{10}$ of a second of arc is one that even the best modern transit instrument is hardly capable of shewing satisfactorily.

THE THUNDERSTORM OF 26TH OCTOBER, 1888.

By H. C. RUSSELL, B.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W., November 7, 1888.*]

THERE are one or two points about this storm that seem to me to be worth recording. On the morning of the 26th there was a remarkably sudden rise in the barometer, but the barometer gradually fell during the day and seemed to be fairly steady, with a tendency to fall. In the afternoon it was evident that a thunderstorm was approaching. At 6.45 p.m. the barometer turned to rise slowly and the storm began soon after with very frequent flashes of brilliant lightning and a sudden change of wind to N. thence round by West to S and S.E., the change, the latter part of it from W.S.W. to S.E. occupying half an hour, during which time the barometer at first rose rapidly for ten minutes to the extent of 0.073 then fell for fifteen minutes at the rate of 0.1 inch per hour, and then very rapidly, so that at the end of half an hour from the time the fall began it had fallen 0.15 inch, which is at the rate of 0.30 inch per hour; the latter part of this fall was almost as rapid as the phenomenal one on the 21st of September last, which you may remember was 0.044 in one minute; in this case it was 0.040 in one minute. So rapid was this fall altogether, that the Redier barograph only recorded a change 0.10 not being able to follow such a rapid change, but the new barograph

on the anemometer shews a fall of 0.15, the same as the standard barograph. Under ordinary conditions such a rapid change of pressure would be accompanied by very violent wind, but on this occasion although there was a squall in which the wind rose to 40 miles per hour, it did not last five minutes, and as a whole the storm brought very little wind or rain, its distinctive feature apart from the extraordinary barometric change being the intense electrical discharges. Some of these were brilliantly white bands 60° and even 70° long, and they gave a dazzling light that illuminated the whole city to such an extent that the photograph I took of one of them shews the outline of the houses from the momentary light of a single flash; and another plate which was exposed for five minutes waiting for a flash in a particular direction has on it a picture of lower Fort Street, the Harbour and North Shore by the light of flashes which were outside the field of the camera, and on the negative the outline of some clouds can be made out distinctly. The first photograph referred to is exhibited and shews clearly that there were a number of lateral discharges from the flash, and it is much more brilliant high up than near the horizon, this may however be due to the nearness of the upper part compared with that near the horizon. The second photograph shews a similar flash evidently much more distant, and near it can be faintly seen one of the curious zigzag flashes that were so frequent between the clouds. This is faint, because like most of them were, it was apparently in a mist; that is seen through a cloud, and in addition had a yellowish colour unfavourable for photography. It will be observed that the brighter flash on this photograph is double for a considerable part of its length, and just before it, I saw one for which the camera was not ready, which was double from top to bottom, i.e. over a length of about 70°. The rain although not heavy prevented me from getting photographs of some of the flashes because it wet the lenses, and I was obliged to get what I could through an opening in the dome.

The majority of the lightning flashes were between the clouds and presented a curious wavy form often very beautiful, but all of these that I saw seemed to be in a yellow mist, as if in the clouds, while all the up and down strokes were brilliantly white, and in number could not have been more than a quarter or one-third of those in the clouds.

The photograph shews clearly that the course of the brighter flash was a very wavy one, like a ribbon blown by the wind; and it looks as if in some places its course had been in the direction of the line of sight; in these parts it would of course be more brilliant from the fact that it was seen end on. This suggests a very satisfactory explanation of a remarkable appearance which is sometimes seen, and which I once observed in Sydney, that is,

when a brilliant flash of lightning seems to break up into short pieces as if they were links in a chain of light, hanging for a moment in the sky; the cause of this is supposed to be that parts are more brilliant than others from being seen end on as above, and therefore make a more lasting impression on the retina, and seem to remain suspended as fragments of the departed flash.

Although the change of pressure in this storm had little effect upon the wind, it produced a remarkable effect upon the ocean as shewn by the tide gauges at Sydney and Newcastle; as the great changes in the barometer began so the ocean felt the influence, rising as the barometer fell, and falling as the barometer rose. Changes in level in some cases amounted to six inches, and the ocean waves having been thus started continued for some hours after the storm was over.

WEDNESDAY, NOVEMBER 7, 1888.

Mr. H. C. RUSSELL, B.A., F.R.S., Vice-President, in the Chair.

Twenty-three members were present.

The minutes of the last meeting were read and confirmed.

The certificates of three candidates were read for the third time, of five for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Adair, John Frederick, M.A., *Camb.*, Sydney.

Bedford, Alfred Perceval, Sydney.

Fieldstad, Axel Hieronyunis, Sydney.

Garrett, William Fry, Sydney.

Megginson, A. M., M.A., M.B., C.M. *Edin.*, Sydney.

Reading, Richard Fairfax, M.R.C.S., *Eng.*, L.R.C.P., *Lond.*,
L.D.S., *Eng.*, Sydney.

West, William Augustus, L.K.Q.C.P., *Irel.*, L.R.C.P., *Irel.*,
Glebe.

In the absence of the authors, Mr. F. B. Kyngdon read the following papers :—

1. "Results of Observations of Comets I. and II., 1888, at Windsor, N.S.W.," by John Tebbutt, F.R.A.S.

2. "Desert Sandstone," by the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.

Some remarks upon the latter paper were made by Profr. Liversidge, Mr. C. S. Wilkinson, and Mr. C. Moore.

Mr. H. C. Russell, B.A., F.R.S., then read the following papers : "On a new Self-recording Thermometer," and "Notes on the Thunderstorm of October 26th, 1888." Two photographs of flashes of lightning, taken during the storm, were exhibited.

The thanks of the Society were accorded to the various authors for their valuable papers.

The Chairman exhibited a meteorite, weighing $35\frac{1}{2}$ lb., which had been found near Mr. J. Russell's station, some distance from Hay. The meteorite was taken to the station by one of the hands, who said that he saw it fall ; but he was evidently under a misapprehension as to that. It had apparently been under the earth for a considerable time. Oxidation was going on so rapidly that it was probable the stone would not last very long.

Professor Liversidge said that the bulk of the Thunda meteorite of which Mr. Wilkinson obtained a specimen in 1885 or 1886, had been presented to him by Dr. Campbell of Yass ; but as he had received it only that afternoon he had not had time to make an examination. It was a metallic one, consisting essentially of iron, more or less mixed with nickel and cobalt. There was also a small quantity of sulphur and phosphorus. Its weight was about 137 lb. The pittings are very large and cup-like, and some of them almost perforate the meteorite.

Mr. Wilkinson exhibited a meteorite, weighing $12\frac{1}{2}$ lb, composed chiefly of iron. It is of an irregular pear shape, and was discovered firmly embedded in slate rock on the highest peak of a mountain near the junction of the Burrowa and the Lachlan Rivers. It was found by a miner named O'Shaughnessy, and given by him to Mr. A. J. Single of Cowra, who forwarded it to the Mining Museum.

A discussion upon meteorites took place in which Mr. E. Baker, Prof. Liversidge, Mr. C. S. Wilkinson, and the Chairman took part.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF OCTOBER, 1888.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

- | | |
|---|----------------------|
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| CALCUTTA—Geological Survey of India. Records, Vol. xxi., Part 3, 1888. | <i>The Director.</i> |

- CHRISTIANIA**—Norwegische Meteorologische Institute. Die Internationale Polarforschung 1882-1883. Beobachtungs-Ergebnisse der Norwegischen Polarstation Bossekop in Alten. II. Theil, 1888. *The Institute.*
- DENVER, COL.**—Colorado Scientific Society. Proceedings, Vol. ii., Part 3, 1887. *The Society.*
- DIJON**—Académie des Sciences, Arts et Belles-Lettres. Mémoires, 3e Série, Tome ix., 1885-1896. *The Academy.*
- EDINBURGH**—Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. iv., No. 8, August, 1888. *The Society.*
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- HAMBURG**—Deutsche Meteorologische Gesellschaft. Meteorologische Zeitschrift, September, 1888. *The Society.*
- HOBART**—Royal Society of Tasmania. Abstract of Proceedings, May 14, June 11, August 13, October 3, 1888. Tasmanian Salmonidae, exhibited in the Tasmanian Court at the Melbourne Centennial Exhibition, 1888. „
- KIEFF**—Société des Naturalistes. Mémoires, Tome ix., Parts 1 and 2, 1888. „
- LONDON**—Anthropological Institute of Great Britain and Ireland. Journal, Vol. xviii., No. 1, August, 1888. *The Institute.*
- Linnean Society. Journal—Botany, Vol. xxiv., No. 163, 1888; Zoology, Vol. xxii., No. 140, 1888. *The Society.*
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THE LATIN VERB *JUBERE*,

A LINGUISTIC STUDY.

BY JOHN FRASER, B.A., LL.D.

[*Read before the Royal Society of N.S.W., December 5, 1888.*]

PHILOLOGY is one of the handmaids of Ethnology. When the ethnic relations of any nation are yet in question, an examination of its language may be the first finger-post that guides us on the way to a successful issue. The testimony of Philology, when taken alone, is not sufficient to settle the question, but, when its teachings are supported by evidence drawn from other sources, the whole may make up such an amount of cumulative proof as will leave little room for doubt as to how the verdict should go. The study of language has already done signal service in the field of Ethnology; a hundred years ago, when the language of the Indian Vedas began to be known to Europeans, it was Philology that led the way in proving the kinship of the nations which we now call the Aryan family, and at the present moment it is Philology that is proving the earliest population of Babylonia, the inventors of the first arts and sciences, to have been neither Aryan nor Shemite. And the labours of distinguished British, French, and German scholars, have, within the last fifty years, so determined the bounds and fixed the principles of Philology, that it may now claim to be acknowledged as a branch of scientific study and to be used as an instrument of scientific discovery.

Now the classic languages of ancient Greece and Italy are still a fair field for philological investigation, for, although much has been said and written about them, it cannot be asserted that we have as yet reached an unchallenged decision as to their relation to one another or to the other old members of the Aryan household. Whatever opinion may be formed regarding the influence of the language, literature, and art of ancient Greece upon her Italian neighbour, yet there is enough of individuality in the native language and religion of Rome to permit us to say, that another and a potent force must have assisted to mould the Mid-Italic tribes into that compact and energetic mass whence sprung the arms of Cæsar and the speech of Cicero.

I purpose, in this paper, to inquire whether the Latin language can, when interrogated, speak for itself and tell us anything reliable about its own origin. Surely it knows whence it came, and, if our examination of it be faithfully conducted, we may expect a faithful answer to our inquiries. Let me, therefore, now call in and present to you one well-known member of the Roman

household, the verb *jubere*; this one cannot be suspected of having any Grecian kinship, for there is nothing at all like it in Greek, and it holds so important a place in the language that it cannot be a borrowed word. Some think that we must go all the way to India to find its place of birth, for Vanîçek ("Wörterbuch der Lat. Sprache") traces it to the Sanskrit root *judh*, "to bind," while Dwight ("Modern Philology") is so hard pressed for an etymology that he has recourse to the clumsy artifice of making it a compound of the Latin words *jus* and *habere*. But even although the root of the verb *jubere* could be satisfactorily shown to exist in Sanskrit, yet the word itself is not there in any form, and it is evident that the Aryan conquerors of India did not bring it into Italy, nor did the Greeks. Who then? Let us see.

I. *The meaning of the word.*—Our dictionaries tell us that *jubere* means primarily (1) to "say" that any one shall do a thing, or that a thing may or shall be done; hence it means (2) to "order," and (3) to "prescribe or decree." In Latin such expressions as, *Dionysium jube salvere, jussi valere illum, sperare nos amici jubent*, exhibit the earliest use of the verb, which is to "say" or express a wish, to "say" something that has reference to others, like the English verb *bid* in the phrases, *Bid him farewell, we bade him good morning*. If I am asked how this mere expression of a wish develops into a positive order or a peremptory decree, I have only to remember that the *patria potestas* in ancient Rome was so wide and binding that a father's wishes were the severest law to his children, and that this paternal discipline, which had power over a son long after he had passed the age of boyhood, so operated that obedience to lawful commands became an essential part of Roman ethics, whether in the family, the army, or the state. Hence those who had authority similar to the *jus patrum*, as kings, civil magistrates, or military officers, had also the same power *vite necisque* which the XII. Tables gave to the *paterfamilias*. Occasions on which this power was used will occur to the recollection of every one who has read Roman history.

II. *The form of the word.*—If I now proceed to inquire what is the parentage of *jubere*, I find that the Keltic language in its insular branch* (and the Keltic is old enough to be the parent

* I divide the Keltic language into three branches, (1) Insular Keltic (= I.-K.), spoken in Ireland, the Isle of Man, and the Highlands and Islands of Scotland; (2) Kymric (= C.), the Welsh, the Cornish, and the Armorican of Bretagne; and (3) the Continental or Gallo-Keltic (= G.-K.), such remains as we have of the Keltic once spoken on the Continent. In referring to other languages, I shall use the following abbreviations: S.=Sanskrit; H.=Hebrew; Gr.=Greek; L.=Latin; Fr.=French; G.=German; A.-S.=Anglo-Saxon; E.=English; K.=Keltic, in a general sense as including the three divisions; P.=Persian; Ar.=Arabic.

of any Latin word, and had besides a location in Italy long before Rome was founded) has a verb *a bair*, "say," with a past tense *thubairt*, "said," and a participle, *radh*, "saying or said." In *thubairt* or *dhubairt*—the form which concerns us at present—the *t* final is an affix and represents the *te* of the past participle (in S. *ta*) of many other verbs, as *fag-te* "abandoned," from the I.-K. verb *fag*; the bare form then is *dhubair*, or, unspirated, *dubair*, *dabair*. Now, if after the fashion of the Hebrew, to which in some respects the Keltic bears a strong resemblance, the preterite be taken as the stem-form of the verb, and if we pronounce the final *r* with a slight vocalisation after it, as was the practice with some languages of old, we have the word *dhubair-e*, to "say"—a very close approximation to the Latin infinitive form *jubere*. Therefore I conclude that *jubere* may be a Keltic word, and, if it is so, that it belongs to the I.-K. branch of the Keltic, for the Kymric has nothing like *dhubair*, nor do I know any other European language which has. Now *jubere* is only one of many words both in the classical and the modern languages which can be traced to the same source as the K. verb *dabair*, and, as I wish to make this paper a linguistic study, I will go at once to that source and step by step unfold the connection of these words with *jubere* and with each other.

III. The original root of all is *dab*, *dabh*, which is a weaker form of *gab*, *gabh*. The interchange of the medial consonants *d* and *g* (and their aspirates *dh* and *gh*) is common throughout the K. languages, and is well established between other members of the Aryan family; there is also, although less common, the interchange of the other medial *b* with *g*, for the S. *go*, *gau*, a "bull, a cow" is the L. *bos*. Children, whose vocal organs are as yet imperfect and weak, constantly substitute *d* for *g* as being easier to pronounce; they say *dood* for *good*. So any word-form which has the initial *g* must be older than any corresponding form with *d*, for it is a principle in language that hard guttural letters have a tendency to change into dentals or labials and then into still softer liquids and semivowels. And, as the first home of the human race was up among the mountain tablelands of High Asia, we may naturally suppose that the root words of the primitive and unbroken speech of mankind were moulded by the environment, and consisted largely of hard consonants with a few vowels, probably only *a*, *i*, *u*. Then, when mankind had become broken up into nations and tribes, those of them that settled on the plains, and specially in warm climates, must have felt the influence of their environment, leading them to adopt the consonants that were easiest to utter and the softest modifications of the vowels, and to ordain that no two consonants should come together without an intervening vowel, and that every syllable should

end with a vowel. Thus I account for the abundance of soft sounds in the languages of Polynesia. On the other hand, where a nation or tribe came fresh from the common stock, and the current of events had made it follow a warlike and isolated mode of life among rugged mountains, its language is likely to retain the harsh features of its origin and surroundings, and thus I account for the peculiarities of the Keltic and some other languages. Of course, the principle of phonetic decay loses much of its force as soon as any language begins to possess a literature, for that tends to fix its sounds and words.

IV. To illustrate the changes which our root *gab*, "to say, to speak," may undergo, I cite the following words:—(1) from I.-K., *gab*, *gob* the "mouth," that with which we "speak," *gabach*, "garrulous," E. *gab*, "to talk much," *gabble*, "to chatter," *gibberish*, "unmeaning words," *jabber*, "to talk indistinctly," *gibe*, "to deride, scoff at," A.-S. *Scotch*, *haver*, "to talk foolishly," *habble*, "to stutter, to wrangle," *yabble*, "to gabble, to scold," *yabcock*, "a talkative person," Fr. *gober*, E. *gobble*, "to swallow hastily"; (2) by changing *g* into its corresponding sharp guttural *k*, *gab* gives the provincial Ger. *kab-beln*, "to quarrel," E. *squabble*; cf. Sc. *habble*; (3) then, by putting *b* for *g*, the root *gab* gives E. *babble*, "to talk much, to talk idly," Gr. *babax*, "chatterer," *bazo*, "I speak, I say," Fr. *babiller*, "to prattle," and, by the insertion of a liquid, E. *blab*, "to talk much, to speak thoughtlessly"; (4) then, by putting *d* for *g*, we have the H. *dabhar*, "to speak"; (5) by softening this *d* into its liquid *l*, we have the I.-K. *labhair*, "to speak, utter, talk," *labh*, "a lip," the external organ of speech, L. *labium*, *labrum*, "the lip,"—a word which belongs to "speech" and not to the "licking" of the tongue, as some Latin etymologists assert.

From these experimental examples we gather the following facts:—(a) *g* becomes *b*, as, *gab*, *babble*; (b) *g* becomes *d*, as, *gab*, *dabhar*; (c) *g* becomes *d*, and then *l*, as, *gab*, *labhair*; (d) *d* becomes *l*, as, Gr. *dakrūma*, L. *lacrima*, L. *delicare* for *dedicare*; (e) *g* become *j*, as, *gab*, *jabber*, *gibe*; (f) *g* becomes *k*, as, *gab*, *kab-beln*; (g) *g*, *gh*, becomes *h* or *y*, as, *gab*, *habble*, *yabble*; the same changes are seen in Ger. *gellen* "to shriek," E. *yell*, *howl*; E. *garden*, Fr. *jardin*, E. *yard*; (h) the sibilant *s* may be prefixed to harden the meaning, as, *kabbeln*, *squabble*; this change probably arises from the substitution of a palatal *ç* for the guttural *g*, for in Sanskrit and in European languages this *ç* becomes *sk*; (i) *l*, as an affix, gives a frequentative force to a verb, as, *gab*, *gabble*; *gob*, *gobble*; (k) the liquid *l* may be introduced into a word, as, *gab*, *bab*, *blab*. Several other principles of change will present themselves, but we shall notice them as they occur.

V. Again, it is very common in Sanskrit and also in Insular Keltic to find the medials b, g, d, aspirated into bh, gh, dh; indeed so common in Keltic that a humorous Gaelic lexicographer declares that there is not a syllable in his language that has not the letter h either expressed or understood! So, if the I.-K. verb *dabair* were made to go back to its original form *gabhair*, the bh, as is usual in such a case where it comes between two vowels, is quiescent, like the digamma in Greek; the same quiescence is common in Hebrew, as, nûr, "to give light," for nabhar. The verb *gabhair* to "speak" would then be pronounced ga-air, which in I.-K. is written ga-ir and means to "laugh, shout, cry," (cf. (e) E. *jeer*, to "deride, mock," and the Icelandic (c) *dar*, "derision"), but in C. *gair* holds to the original meaning of a "word, saying, report, fame," and its derivatives take the form *geir*, as, *geir-fa* "vocabulary," *geir-da*, "good report, fame," *geir-io*, "to use words or phrases." From this ga-air, *geir*, I take the Gr. words *gêrus*, "a voice," *gêruo*, "I utter, speak, cry, sing," and, by softening the initial g into gh or y, which is then lost, I get the Gr. *eiro*, "I say, speak, tell, proclaim, announce"; and here the occurrence of the initial g in I.-K. and in C. explains many of the difficulties that face the etymologist in endeavouring to account for the anomalies observed in the cognates and derivatives of the Greek verb *eiro*, and proves in opposition to Curtius ("Greek Etymology") that *eiro* has Oriental kinsmen, for K. *gaair*, *geir*=*gabhair*=*dabhair*=H. *dâbhâr*, as will be shown presently. Further, the Greek verb *eiro*, "I say," when in its middle voice *eiromai*, *eromai*, means "I ask," just as the E. *ask*, A.S. *acs-ian*, *asc-ian* is probably formed by a transposition of the s of the syllable *sag*, the G. root of *sagen*, to "say"; so the supposed K. word *ga-air*, for *gabhair*, may soften the initial g (gh) into y and become *iarr* (for *yâ-irr*), and this is the common verb in I.-K. for "to ask, inquire, seek," also "bid, desire" in the sense of "ordering," which shows its connection with the root *dabar*, *ut infra*. So far in this paragraph I feel my footing to be sure, but in the remainder of it I must walk warily. You will grant me that the form *ga-air* is assured and from it *ka-ir* (f); now, just as the I.-K. *koig*, *kuig*, "five," is the L. *quinque*, so I believe *ka-air* gives me the L. *quaero* "I seek," *quaeso* "I ask, beg, intreat" (to be pronounced *ka-ero*, *ka-eso*), and their connection with the root-meaning of *gab* is illustrated by the Fr. *causer*, "to speak, discourse, prattle, babble," and *jaser* "to prate, chatter." If the L. verb *quaero* be thus etymologically the same as *gabhair*, *dabhair*, then the established notion in phonology that s precedes r in time admits of exceptions; for although grammarians hold that in Latin the form *lases* is earlier than *lares* and *laebesum* than *liberum*, yet in this case *quaero*

must be earlier than *quaeso*. Strange to say some light may be thrown on this point by the language of our much misunderstood blackfellows of Australia; the district which we call Yass was by them called Yarr, for they have no *s*, but Yarr was by them so pronounced that the early settlers there took the name to be Yass. But further, as to our root *gab*, if I were to declare to you without explanation, that the Greek noun *erōs*, "love," is derived from *gab*, *you* would at once declare that philology was gone mad, but I will show you the path by which I reach *erōs*. The *L. quaero* means "to seek-to-obtain," "to desire," "to aim at" (= *L. ap-pet-ere*), which meaning is clearly brought out in the participle *quaesitus* with its compounds, and in the noun *quaestus*, "gain"; you also see that the *I.-K. iarr*, for *ga-air*, "to seek," is the same word as the *L. quaero*; now a participial noun from *iarr* is *iarr-aidh* or *iarr-oidh*, "an asking, a desiring, a soliciting," and this seems to me to be the same word as *erōs*, *erōt-* (as if *yerr-oids*) "love, desire, appetite," which also is a participial form in Greek; this derivation of the word is supported by the *Gr. verb erōt-ao* (from *erōs*), which reverts to the first signification of "asking." If the derivation which I now suggest is correct, then I understand why the use of *erōs* in Greek is so different from that of *storgē* and *agapē*, for they are applied only to the "love" of parents, children, and friends.

Before leaving this paragraph I will take stock of the phonetic principles which we have observed in it:—(*l*) the medials *b*, *g*, *d*, are often aspirated into *bh*, *gh*, *dh*; (*m*) *bh* (= *ƒ* the digamma) and *dh* are often quiescent between vowels; as, *I.-K. du-bh-acas*, *bui-dh-e*; *Gr. ogdo-ƒ-os*; *H. na-bh-ar*, *nūr*; *I.-K. ga-bh-air*; (*n*) initial *g* is often dropped, as, *S. giri*, "mountain," *Gr. oros*; (*o*) initial *g* = *k* = *L. qu*; (*p*) transposition of letters, especially of *l*, *s*, and *r*, in the same syllable, is common; as, *H. targ-umin*, "translations," = modern Persian *drag-oman*, "an interpreter," *H. kesebh* = *keh-bes*, "lamb"; *Gr. kartos* = *kratos*, "strength"; *E. grain*, *garn-er*; *E. horse*, old *Ger. hros*, *S. hresh*, "to neigh"; (*q*) *r* changes into *s* and *s* into *r*, as, *L. lares*, *lases*; (*r*) participles are used as nouns, as, *L. animans*.

VI. I wish now to call to your recollection the fact that when language was first formed,—I will not say, invented, for I believe the faculty of articulate speech to be a special gift from heaven—the form of the root-words in use must have been simple, and the number of them small, corresponding to the limited wants of man. As to the form of these primitive root-words, in the Aryan family they were essentially monosyllabic and biconsonantal, that is, they were words of one syllable, consisting of two consonants combined with a vowel either between or after them; as examples we have the *S. kri*, *kar*, "to make," *Gr. phil-os*, "friendly," *L.*

bib-o, "I drink," K. faic, "to see." As to their number, it is impossible now to hazard even a guess, but I imagine they were few. Still, it would be interesting to know what were the originals of human speech; if we had them all collected before us, we might look on them with reverence not unmixed with curiosity, as the prolific patriarchs, now thousands of years old, whose offspring in countless millions have spread themselves throughout the whole earth, and, like obedient genii, now come forth to work wonders at the bidding of the brain and tongue of man. If an etymologist had leisure and industry enough, it might be possible to make such a collection of root-words in the Aryan family, and much easier to do so for the Shemitic family where the languages are not numerous nor the literature so extensive. In the Shemite tongues, the form of the roots will be found to be essentially triconsonantal, the vowel points being used to facilitate pronunciation; and many of these stem-words are formed from biconsonantal primitive roots by affixing a third consonant. For example, our Aryan root gab, "to speak," is also called dab (*b*) or dabh, and this, by the addition of the letter r, becomes the H. verb dabhar "to speak." There is, no doubt, a number of monosyllabic roots in the Shemite tongues, but many of these are really dissyllables contracted, as kām for kāvām; thus also dabhar might become dār. I have said that the original words in human speech were probably few in number; and, by numerous figurative applications of the primary meaning of each root-word, the varying wants of man were expressed. This process still goes on in language, although only to a limited extent; for instance, we have recently learned to say, Will you "wire" to London? where the noun *wire* remains unaltered in form, and yet has undergone two changes, for it has become a verb and has received an artificial application of its meaning. In further illustration of these principles I will return to our root gab, "to speak." The *b* on Oriental lips is scarcely distinguishable from *m*; both are labials, and are so good friends that they quietly slip into one another's places, often unobserved. So gam is the same as gab. Now there are in the Aryan languages about a dozen root words all sounded gam; there is 1. gam to speak, 2. gam to seize, 3. gam to hollow out, to dig, 4. gam to bow down, 5. gam to cover, protect, 6. gam to love, desire, 7. gam to go, 8. gam to leap, 9. gam to twist, 10. gam to tame, subdue, 11. gam to marry, 12. gam with, together, and 13. gam to join.* You may ask me how it was possible for a hearer to know in conversation which gam the speaker meant. I

* Even the best dictionaries confound these roots. Benfey has S. "kams, kaç, or kas, to go, to command, to destroy." The second and third of these meanings belong to our root gam (see page 354), but the first is from gam, to go.

answer that it was just as easy as for us to understand the difference between—"the bell was tolled, he was told to go away, a crew of eighty men, all told;" or for a Hebrew, reading his Bible without points, to know which of its six meanings the word *db̄r* has, when he sees it. And yet I do not assert that all these words *gam* are distinct and separate roots; by figurative applications of their first meaning they group themselves together; thus 12 and 13 are the same word; so are 3, 4, 5, 6, 11; so also 7 and 8, and probably 2 and 10. Our word *gam*, "to speak," seems to stand alone, but nevertheless it has kindred all over the world; one kinsman is often in the mouths of the blacks of Equatorial Africa, for they say, *mi kam-ba*, "I speak," *gamba* "speak." In New South Wales also, the aboriginals of the Illawarra district say *kam-ung*, "to speak." Here we have proof of the unity of language, and hence, of the unity of mankind; for the root *gam* means "to speak" in the Hamite tongues as well as in the Shemite and the Aryan. An objector will say that it is a mere coincidence that *gam* should mean "speak" among the Hamite tribes of Africa and Australia. But any mathematician here present can speedily tell, by the use of his algebraical formulæ, how little probability there is that any three letters of the alphabet, even although it be reduced to eighteen or sixteen letters, should arrange themselves by mere chance into the form *gam*, "to speak." For this and many other reasons I believe in the kinship of languages.

VII. I now proceed to consider *the root and cognates of the Latin verb jubere*. In the conjugation and declension of the I.-K. verb under consideration, four forms are used, viz.:—*abair*, *dubhair*, *their*, and *radh*, as, *an abair mi*, shall I say? *cha dubhairt mi*, I said not; *thubairt mi*, I said; *ma their mi*, if I shall say; *ag radh*, saying (literally, "at-saying," "a-saying," like E. *a-going*). This variety of form shows it to be a very old and a very common verb; for the same variety occurs in the S. verb *brû*, "to speak," (which is assisted in its congregation by *vach* and *ah*) and in the substantive verb "to be" everywhere. I have already explained that the simple root form of this K. verb is *dabair* or *dubair*, and for the sake of comparison I now bring in the H. verb "to speak," which is *dabar* or *amar*. This I do not because the Hebrew had any share in forming the Keltic or the Latin language, but because Hebrew is a very ancient language, and any words which are found both in it and in the Aryan must belong to the earliest forms of human speech. Root words have also preserved in Hebrew many of the figurative shades of meaning which enable a philologist to show the connection of their derived words in other languages. And the H. verb, *dabar*, "to speak," is so like the K. conjugational form *dhubair*

as to justify the belief that they are the same word, notwithstanding the assertion of some that the Shemitic languages have no common origin with the Aryan. Now dhabair, that is, dhubair, is pronounced habair, from which, by dropping the initial breathing, I have the abair of the future, that is, the present, tense of the K. verb. Similarly, although Gesenius in his Lexicon does not notice it, the H. form amar is got from dabar by dropping the initial d (as in the Kymric, am, "round about," for dam), and changing b into m. This relationship is the more likely because the Hebrew verb dabar might be written dh-amar, while the initial a of amar is the soft guttural vowel *aleph* which is almost equivalent to a silent h, the h which represents dh.

It will be convenient here to refer to the fact that in Sanskrit there is a wonderfully large number of verbs that mean "to speak," (I have counted more than twenty in Benfey's Sanskrit Dictionary) besides many others that mean both "to speak" and "to shine."* I for one cannot conceive how any language can require twenty different verbs all meaning the same thing, and so I infer that these twenty, or at least many of them, all come from one single root, modified sometimes by caprice, as when a Samoan says namu for manu without any reason for the change, and sometimes modified to suit the shades of meaning which the speaker intends to convey. These modifications usually proceed on the principles for the change of consonants already noticed, but, in some words, like the Samoan nam for man, the root syllable is reversed. This kind of change happens more frequently, I think, than etymologists are willing to acknowledge. Many word-forms could be accounted for by the operation of the principle of the reversal of the root, "end for end," as seamen say. As instances I quote the C. gaf, and the E. dagger. The Kymric gaf, "a bent hold or hook" is the same as the C. bach, "a hook, a crook, a grappling-iron"; bach is only gab reversed and the g aspirated; so in E., the dagger is that which pierces, stabs, and the gad-fly is the fly that pierces the skin to deposit its eggs; gad is dag reversed. Then also, it is curious to observe that verbs "to speak" also mean "to shine." How is this to be accounted for? the two ideas are so unlike. There are some distinguished astronomers in this Society, who know all about the sun, the moon, and the stars. Can they tell me why the sun is represented in old almanacs and in the emblazonry of fire-insurance offices as a full, rosy face, with

* To show their connection with our root, I would arrange these Sanskrit verbs thus:—From root *dab*, S. ramh, ru (for rav), rap, raj, jap, lap; hve and hu (for hav); from *vad* (for dabh=dav), S. vad, bhan, bhand; from *gab*, S. gabda, gad; from *vag* (for gabh=gav), S. vach (vakti, ukti), valk, ah (for ag); from *a Bair*, S. barh, varh, brû, bhrimç; from *radh*, S. arth.

puffed cheeks and staring eyes! We have heard that there is a man in the moon, and, if we may trust our boyhood's nursery tales, he sometimes opens his little wicket, when stray visitors from our planet go so far, and speaks to them; but have our astronomers ever seen a man in the sun, and can he speak? If they cannot tell, an answer will be given by the student of language. From it we learn that the ancient makers of language regarded the sun as the all-seeing one, the eye of Dyauspitar, the eye of heaven; hence in the Egyptian hieroglyphics the picture of an eye is the symbol for the sun. Now, they noticed that just as the sun gives forth rays all flowing in regular order from one central spot, so words proceed from the speaker all in orderly array, and issuing from one common source, the mouth.* Thus to speak and to shine came to be expressed by the same word.† Indeed the English word "speak" is a proof in point; for our dictionaries tell us that it means to utter words, or articulate sounds, in order; and they connect it with the Italian word *spiccare*, "to shine, to shoot forth rays." The same word is seen in the expression "spick and span," = bright, shining, new.

To sum up the principles which we have recently ascertained, I would remind you that (*s*) *bh* initial is in sound equivalent to *v* or *f*, the Greek digamma, and that *dh* initial sounds *h*; both *bh* and *dh* between vowels are often quiescent, and may be dropped at the beginning of words; (*t*) *b* and *m* are cognate sounds; (*u*) syllables are added to words to form verbs, nouns, participles, &c.; thus, the I.-K. adds *air* for verbs and nouns, *ain*, *an* or *inn*, for nouns, and *adh*, *aidh*, *oidh*, *uidh*, for participles; in fact the participle is a noun, and to it an additional syllable may be given for word-building purposes.

VIII. Having now established the principles (*a* to *u*) on which the changes in our root-syllable proceed, and their effect in word-building, I will, in this paragraph, write down a list of the most common cognates of the Latin verb *jubere* as found in various languages, and I divide them into classes according to the significations which Gesenius gives to the H. verb *dabar*. He says that the primary power of this word is that of—

1. Setting in order, ranging in order.

Cf. E. order, regular arrangement, rule; I.-K. *ordugh*, arrangement; *earr*, array; *earr-adh*, armour, clothing;

* The Latin noun *radius* (see page 357) is another illustration, for it means both "a ray of light" and the spoke of a wheel." This helps to show why the figure of a wheel was used in the old almanacs as a symbol for the sun.

† This explains the divergence of meaning among the derivatives of the Gr. root-verb *phao*; for *phao* gives *phemi*, "I say," but also *phaino*, "I show," and *phaeinōs*, "shining."

sread (L. series), a row; C. rhes, a row, a rank; rhestr, array, row, rank; rhesu, to set in a row; L. sero, I knit; Gr. eirō, I fasten together in order; P. rada, a line, a row; Ar. rasm, a rule, a custom; S. rathya, a wheel; rath, to speak; L. radius, a ray, a *spoke*.

2. To lead, guide (flocks or herds); to guide; to rule, direct; to bring into order, subdue.

Cf. I.-K. riagh-aíl, a rule; iom-ain, a drove of cattle; C. rheol, rule, order; L. rex, a king, rego, I rule, regula, a rule; C. gwedd, order, shape; a yoke, a team.

3. To follow (since the shepherd also follows the flock), to be behind, to be last.

Cf. I.-K. deire, rear, end, conclusion; deire-annach, last, behind; C. gwedi, wedi, after, later on; Gr. hepomai, I follow; L. dorsum, the back; Ar. dubr, the back.

4. To come behind, (and so) to lay snares, plot, destroy.

Cf. Ar. dabar, destruction; H. dabher, pestilence; S. radh, to kill, destroy.

5. To put words in order, to speak.

Cf. I.-K. labhair, abair, to speak, say, dhubairt, said; bruidh-inn, speech (cf. S. brú, to speak); raidh, to speak, to say, to threaten; raidh, a rank, a speech, a threat; raidse, an idle talker; arsa (for radsa), he says; labhairt, briathair, speech; ebirt (O'Clery), to tell; a saying, a word; S. tan abraivit, he said to them; Goth. quithan, to say, tell; E. quoth, L. in-quit, he says; L. for (=fa-vor), fari, to say, fab-ula, a story; C. llafaru, to speak; llafar, voice, speech, utterance; siar, an articulate sound; siarad, to speak, to talk or discourse; eb, ebu, hebu, to say, to utter, to speak; eba, says, quoth; medd, says (Fr. mot, Gr. muthos); gwed, an utterance, a saying; gweddi, supplication, prayer; gwedyd, to say, to speak; L. ser-mo, speech; Gr. eirō, I say; epos, a word; eipein, to say; Ger. reden, to say.

6. (H. amar) To say in one's self, to think.

Cf. C. bryd, the mind, thought; tyb, opinion, thought; tybio, tybied, to think, suppose; L. ratus from reor, for radh-or (s), I think; A.-S. deman, to think; E. deem; C. meddwl, to think, intend, suppose.

7. To speak often; hence (a) to promise (like the G. zu-sagen); cf. I.-K. raidh, tabhair to promise; (b) to command; cf. I.-K. orduigh, riaghlaigh, iarr to command; (c) to admonish; cf. I.-K. earalaich, comh-airlich, to admonish; C. archar, a chiding, rebuking; (d) to demand; cf. C. arch, a request, a demand; archedig, that which is demanded, gofynedig, asked, questioned, gofyn, to demand, ask,

desire; (e) to guard, restrain; cf. I.-K. *arach*, restraint, authority; C. *archado*, to guard; (f) to utter a song; cf. I.-K. *abhnan*, *rann*, *dan*, *duain*, a song; *duanog*, *luanog*, a sonnet, *bardachd*, a song; C. *gwawd*, a song of praise; mockery (cf. *dar*); E. *tabur*, a musical instrument; E. *bard*.

8. To pronounce sentence, to condemn.

Cf. I.-K. *breith*, a judge; *barn*, a judge, a battle; *daor*, to sentence, doom; *raidh*, a judge, an appeal; C. *barnu*, to judge; *barn*, judgment, a sentence; *brawdio*, to pronounce judgment; *defryd*, a verdict, sentence; *dyfarnu*, to condemn.

9. Hebrew derivatives from *dabar* also mean—(a) a word; cf. I.-K. *brathar*, *duan*, *briathair*, a word; C. *gair*, a word, *geirda*, a good report, *fanie*, praise; *geirfa*, a vocabulary; *geiriol*, wordy, garrulous; L. *fama*, report, fame; *laus*, praise; Ar. *lafz*, a word, speech; H. *dabhar*, a word; (b) discourse; cf. I.-K. *labhairt*, a talk; C. *siarad*, talking, a talk; (c) a precept; cf. I.-K. *reachd*, *riaghail*, a precept; C. *arch*, a request, demand; (d) an edict; cf. I.-K. *ordugh*, *reachd*, an edict; (e) counsel; cf. I.-K. *comh-airle*, advice; *sior*, advice; (f) a rumour; cf. I.-K. *radh*, *iom-radh*, a rumour; C. *gair*, a rumour; Ar.-P. *khabar*, news, intelligence; (g) (that which is spoken), a thing, a thing done; cf. I.-K. *obair*, *adhbhar*, *gradh*, *rud*, *rod*, a thing; like the Norse, *ding*, a thing, which originally meant a discourse; L. *res*, a thing; (h) a cause, a reason; cf. I.-K. *meam-hair*, *brigh*, *adhbhar*, *aobhar*, a reason; *tabhair*, to reason; L. *ratio*, a reason.

IX. I wish now to prove that the I.-K. forms *dhubair*, *abair*, *their* and *radh*, used in conjugating the verb to speak, are, all of them, modifications of the same root from which these cognate words come, and that root is *gab* or *dab*. And this is *prima facie* possible, for such verbs are the current coin of every day life and, like the numerals, the pronouns, the substantive verb and some other verbs, are in constant use, and, by attrition, become much corrupted and disguised because of the frequency and rapidity of their utterance. To prove that (1) *dhubair* is a stem, I cite from the list the words *dhubairt*, *labhairt*, *tabhair*, *llafar-u*, *daor* and *duan*. Of these only two require explanation; *daor* is for *da-bh-air* (*m*) and *duan* is for *da-bh-ain* (*m*). I think that the S. verb *vad* "to speak, address," (cf. Gr. *hudeo*) and, in its compounds, "to command, reprove, declare, play on an instrument," is only the root-form *dabh* (*dav*) transposed, for while the S. says *vad*, a musical instrument, the P. says *daf*. I take *dab*, *dabh*, and not *vad*, to be the original form, for the

Hebrew, the Syriac, the Chaldee, the Arabic, and the Keltic all agree in having *d* as the initial letter; and *dab ar* itself is a very old word, for it occurs frequently in the oldest books of the Hebrew Scriptures. Then (2) *abair* comes from *dabair* by aspirating the *d*, which then becomes the breathing *h* and is lost (*s*); thus we get *eb*, *ebu* (in composition *hebu*), *epos*, *eipein*, *hepomai*, *abhr-an*, *obair*, *aobhair*. Corresponding to the loss of the *d* here, a familiar example of a similar effect of aspiration occurs in the Greek word *deilē* = *eilē* = *helē* = Ion. *aleē*, which is connected with the I.-K. adjective *deal*, *geal*, "bright" in its primary tense. Of the K. words which I have now cited, *obair* is so like the L. *opera*, *opus*, that Ebel places it among the words which the Latin has given to the Keltic. If *obair* is a loan word, the Keltic is the lender, not the borrower, for *ab-air* (*u*) is a legitimate formation in Keltic from the root *dab*, *ab*. And so it has fared with other words which the Keltic, although the original owner, is said to have borrowed. Again, by dropping the initial *a*, we have *bar-n*, "a judge," E. *baron* of the Court of Exchequer, and, by metathesis and the addition of a participial ending, we have, *bru-idh-inn*, *brawd*, *bryd*, *breith*, *breath*, *brathar*. And of these, if we take *breith* "a judge" in its uncontracted participial form, *ab-air-adh*, "judging," and to this add *-air* to denote the personal agent (*u*), we have *ab'rath-er* and by metathesis the L. noun *arbit-er*, "a judge, an umpire." This I consider a more natural and a more satisfactory derivation than that accepted by Curtius, Corssen, Vanček and others—from *ar* for *ad* "to" and *ba* for *ga*, "to go." And as *arbit-er*, like *jubere*, is a purely Latin word, I maintain that this derivation materially assists to establish the close connection of the Latin with the Keltic. And further, if, to the form *bair*, which exists in I.-K. in such words as *bair-se-a-ch*, "a scold," *bairsich*, "to scold," (cf. H. *dabar*, "to admonish") I add the K. termination *amh*, I get *baramh*, "a word"—a form which is found now only in the Irish adjective noun *baramh-aíl* "an opinion," (cf. H. *amar*, "to think"). This *baramh* would be sounded *baruv* or *barv*, and *barv*, by merely transposing the aspirate from the end of the word to its beginning, gives the L. *verb-um*, "a word." Connected with *bar*, *barv* is the E. word *brawl*, as to which our puzzled etymologists say as usual that it is formed from the sound. By adding the frequentative letter-syllable *l*, *barv* becomes *barv-el* = *brawl*, "to talk much," hence "a noisy quarrel"; and from *bar* by reduplication comes the Gr. *bar-bar-izo*, "to talk in a foreign tongue," of which, so far as I know, no derivation has yet been offered. (3) Next as to the conjugation form *radh*, I observe that the present participle of *abair*, if written in full, would be

abairadh, then abradh, bradh, and radh, and the last is the existing form; although the other forms have disappeared by attrition, yet from bradh comes the Aeolic Greek brētōr, an "orator," while radh gives the G. reden "to speak," which in A.-S. retains the initial b, as in ge-bredan, "to charge," up-ge-bredan, "to cry out against," E. upbraid. In the etymology of upbraid, our English dictionaries can trace it no farther than to the Anglo-Saxon. Also to the form radh belongs the Gr. verb phrazo, "I tell, order, counsel," Middle, "I speak with myself, think, suppose," through the K. participial form bh'radh; phraz-o would thus mean "speaking-I," or rather, since the participle is really a substantive, "speech-I." And although in Homer phrazo means to "show or signify," that does not affect the derivation I offer, for Gesenius says that the original meaning of the H. amar is to "bear forth, to bring to light"; cf. H. nagad "to show, tell," which means also to "be manifest, clear."

From radh come the K. words raidh, raidse, arsa, rud, rad, and the L. ratio, reor, rat-us, res, and probably rad-ius in the sense of "setting in order," (H. dabar). The I.-K. ar-sa, for rad-sa, is used only when the words of the speaker are quoted, like the E. quoth and the L. inquit. In this respect it is an exact parallel to the Hebrew amar. Again, from radh comes the I.-K. noun radh-ainn (*u*), and, by metathesis, we get the I.-K. ord-uigh, the L. ordo, ordin-, and the Fr. ordonner, corresponding with the E. order. Although radhainn means now only "a saying, an expression," yet if we have respect to the primary meaning of dabar, viz., "to set in rows, to arrange in order," in that sense radhainn=radin=ardin=ordin would be exactly the L. ordo, ordin-; besides that sense, ordonner, and order also retain the meaning of dabar, "to command." If I now revert to the root gab, to speak, I find that in the K. languages f often represents an initial g, as, fear, gwr, a man; so gab gives the L. fab-ula, and on the strength of the b in fab-ula I say that the L. for is a contraction of fa-bh-or (*m*), and fat-us is fa-bh-te, a K. participial form. And (4) if we take dhabh-air and pronounce it with the bh quiescent, we have dha-air, which gives dheir, their and the Gr. eirō (*s*), a word that has caused etymologists so much perplexity. From their come the K. deire, deire-ann-ach, and the L. dorsum. As cognates to the Gr. eirō, the K. has earr, earradh, oire-amh-n-uigh,* earralaich, comh-air-lich.

The rest of the words in my list (on pp. 354-5) may be arranged thus: from *dabhair*, tyb. tabor, defryd, dyfarnu, adhbhar;

* This is a good example of K. word-building; oire is the root, oire-amh an adjective, oire-amh-ain a verb, and oire-amh-ain-uidh is a participial noun.

from *gabhair*, *gofyn*, *gwawd*; from *abair*, *ebirt* (found in old Irish MSS. by O'Clery), *abravit*, *bru*; from *radh*, *radh*, *radius*, *rada*, *rasm*, *rath*, *rathya*, and *rann* for *radhainn*. *Bard* is for *abairadh*, and *brawdio* is from *bard*; *rheol* is for *riaghail*; *arch* is for *argh* (= *ragh* or *radh*); *iomain* is for *dham-ain*, and *dan* for *dabh-ain*; *laus* is for *labhadd*; *brigh* is for *abairraigh*.

X. Having thus, as I think, proved that in I.-K. the conjugation forms in question, viz., *dhubairt*, *abair*, *their* and *radh*, are simply corruptions and adaptations of the primitive root *gab*, *dab*, I will now introduce some explanations of several of the words given in the lists above, and some further proofs that the Latin verb *jubere* is taken from a root that means to "speak, to say."

(1) The root *gam*, "to love," already mentioned, is evidently the same word as the L. *amo*; so our *gam* may become *am*, *amh*, *av*; hence I consider it probable that the Gr. verb *oiomai*, "I think," (as if *aiv-omai*), comes from *am*, especially as the H. verb *a mar* means not only "to say" but also "to say in one's self, to think," and this is exactly the force of the Middle Voice in *oiomai*. The L. *aio*, "I say," also belongs here, although it is usually taken from a root *ag*, as in L. *ad-ag-i-um*. Again, if I affix to *am* the C. participial form *add*, I have *amadd*, which is the C. *medd*, "says," and the C. verb *meddwl*, "to think, to suppose," and *meddyd*, "to say." I also take the A.S. *deman*, "to think, to suppose," E. "to deem," from our root *gam*, *dam*, as well as the E. *damn*, "to sentence," *doom*, "sentence, judgment"—a derivation which shows their connection with the eighth meaning of *dabar*, as we see it in the I.-K. *breith* "a judge," *daor*, "a sentence." Our dictionaries derive the E. *damn* from *damage*, but, in A.-S. Scotch, *dem-ster* is the "hangman," who executes "sentence"; so also, the I.-K. *riagh* is a "gallows," *riaghair*, "a hangman," and *riadh-lann* is a "house of correction." Here we observe the interchange of *dh* and *gh*, so common in the K. dialects, *dh* being the earlier participial form. From *riadh-lann* I infer that *riadh* originally meant "punishment, correction," although its meaning now is "interest, rent, hire" (cf. L. *ratio*). From *riagh* for *riadh* the I.-K. has *reach-d*, "a statute, a law, command, authority," and its derivatives, some of which, as *reach-dair*, "a ruler" (L. *rector*), look surprisingly like loan-words, but are in reality formed in a regular manner from a root that is native to the K. language. And since *riagh* and *riadh* (= *raidh*, *radh*) are the same word, then *riagh-ail* which means "to set in order" (the original sense of the root *dabar*), "to govern, to rule," is a genuine K. word, and so is *riagh*, *righ*, "a king"; although these words are so like the L. *rex*, *regula*,

and *rego*. *Rego* originally means "I set in order," as in *rectus*, "straight"; and so the *L. rex* is he who "sets in order, corrects, chastises, dooms, commands, rules, governs." The Oscan ruler-name *MEDDIX* has a similar signification, for, in my opinion, it belongs to the I.-K. verb *smachdaich* "to correct, chastise, rule, govern," *smachd* "correction, rule, the authority of master over a pupil, reproof." That *smachd* and *riadh* are synonyms is apparent from the fact that the I.-K. *smachd-lann* and *riadh-lann* are both used to mean "a house of correction." I form *MEDDIX* from *smachdaich* by adding the Etruscan personal formative *th* which in *L.* becomes *s*, as Etruscan *Lar-th* = *L. Lars*; thus *smachdaichth* = *smachdaix* = *meddix*. And the I.-K. *smachd* is a very old word, for it is the *H. macha*, "to smite, strike," hence "to hinder, restrain," and this reminds us that, on the testimony of Herodotus, the Persian regal title, *Darius*, means the "restrainer"; with this compare the *S. vinetri*, "ruler, a chastiser, a teacher." The initial sibilant in *smachd* is nothing unusual, for a similar *H. verb machah*, "to wipe," is in Greek *s-mēcho*. Philology tells us that the modern notions about the duties of a king are of a milder kind, for king is said to mean etymologically either the "father" of his people, or the "kenning, knowing, able" man. Nor is *MEDDIX* the only Oscan name which may have a *K.* origin, for the epithet *tuticus*, applied by the Oscans to one of their supreme magistrates, may be from the *K. tuath* meaning "the common people," while *deketasius* applied to the other, as on the Cippus Abellanus, seems to me to be the I.-K. *taighadh*, "protecting, covering," from the same root as *K. taigh-earna*, "a lord," and the *L. teg-o*; in the same way as the *L. patronus*, *patricius* imply the duty of patronage and protection. Thus the *meddix tuticus* and the *meddix deketasius* will correspond with the Roman *tribunus plebis* and the *tribunus celerum*, the one representing the common people and the other the patricians.

(2) From our root *gab*, I form a participial noun *gabhadh* or *gabhad*, and a verb *gabhad*, which are legitimate forms although they are now lost; but from them come numerous *C.* words which show many of the meanings of the *H. dabar*; thus, *C. gwed*, "a saying," *gwedi*, "after" (cf. I.-K. *deire*, *Gr. epi* and *hepomaí*), *gwedyn*, "afterwards," *gwedwr*, "a speaker," *gwedyo*, "to say, speak," *gwedd*, "order, shape, fashion" (cf. *L. ratio*), *gweddi*, "prayer, supplication," *gweddu*, "to render orderly, yoke, wed," *gwawd*, "a panegyric," *gwawdeu*, "to jeer" (cf. *E. gibe*), and, with *d* for *g*, *dywed*, *dyweyd*, "to say, speak." The *C. dywed*, *gwed*, "to say," brings us to the Gothic *quith-an*, "to say, tell," whence the *E. quoth*, "saith" (used, like the *H. amar*, only when the speaker's words

are quoted), and the L. in-quit. The supposed noun gabhadh, from which all these words come, if pronounced as usual with the bh quiescent, would give a form ge-ad, whence the I.-K. cead-ach, "talkative," and cead-al, "a story," but, if it is written in a C. form, g'vadd, it gives C. gwed and the other words quoted.

(3) Of the words which I tabulated under the meanings of the H. dabar, there remain to be considered only the Gr. eiro, "I fasten," L. sero, series, sermo, I.-K. sread, siarad, C. rhes, rhestr. As to their derivation from our root gab, dab, I cannot give any decided opinion, although two of them in the sense of "discourse," sermo and siarad, point to a connection with the verb "to say." The I.-K. conjugation form their (= seir) would easily give the Gr. eiro and the L. sero, as well as the I.-K. sread, and siarad, while the C. rhes may be for s-res from the same root; yet there is in H. another verb, quite different from dabar, viz., shôr (for shârar) "to arrange, put in order, and as sharar may have an equivalent in Aryan somewhere, it is probable that the Gr. eiro, "I fasten" and the L. sero, "I knit," are not from the same root as eiro, "I say," and sermo, "speech." Indeed as the H. sharar or zarar has the other meanings of "to twist, twine, press, oppress, bind together, shut up, distress," we should rather say that, through some Aryan corresponding root, it connects itself with the Gr. seira, "a rope," eiro, "I fasten, I bind," heirgo, eirgo "I shut in, confine," and the L. sero "I knit," with all their cognates. But the L. sero, "I sow, I plant," must be connected with dabar, for serere arbores means to set or plant trees "in rows."

XI. I now conclude with one final proof that my view of the etymology of the Latin verb jubere is correct, and I find that proof in the Latin noun Imperator. It is obvious from the meaning and use of the Latin official term dictator, which is taken from dicere, "to say," that one invested with the very highest power in the State may have a title drawn from the fact that he can "say" with force that a thing shall be done. Now Imperator is known to be a corruption of an older word induperator and, if we strike off from this the personal suffix ator, we have induper as the stem, and this to my eye is no more than the I.-K. intensive particle ain and the verb dubair, dhubair, dabar, which we have been considering.

XI. A few reflections may be drawn from this discussion.

(1) If the analogies which I have traced and the arguments which I have advanced be, on the whole, correct, then the Hebrew as a Shemitic tongue has a much more intimate connection with the Aryan family than many philologists are disposed to acknow-

ledge, and the link of connection between the two families is most easily traced through the Keltic.

(2) Elementary monosyllabic roots, denoting the primitive ideas in human speech, are capable of receiving and from frequent use are likely to undergo numerous changes of form and application ; and so, although some maintain the contrary, the earliest root words of the undivided language of mankind may have been comparatively few in number.

(3) As the original seats of the human race were mountain regions and elevated tablelands, it is probable that the earliest speech was in harmony with the physical experiences of the people, and consisted largely of hard and even harsh consonant sounds. The Hebrew and the Keltic still retain these features, and in my opinion are specially worthy of the attention of philologists, while the Sanskrit and the Greek exhibit the softening influence of climate and separation from the parent language.

(4) The Kelts, having been the first, probably, of the Aryan races to occupy the south and west of Europe, may have left a considerable portion of their own population and of their own language in those localities where they dwelt, and there we may reasonably expect to find traces of their influence. The fashion at present supreme among philologists, that of referring everything in Latin and Greek to Sanskrit as the only umpire, seems to be both unwise and fallacious. The plea that Sanskrit possesses written records of great age is equally cogent in favour of Hebrew, and if any Keltic words can be shown to have an identity with the Hebrew, this should be taken as establishing the antiquity of these words, in the absence of an ancient Keltic literature.

(5) The important part which the digamma plays, in the etymology of Greek words, may lead us to admit that many words may have come from the Keltic into the classic languages through the suppression of the sound of bh, which, in fact, in modern Keltic is often quiescent, as in Hebrew.

(6) If *jubere* and many other words essential to the Latin language are purely Keltic, if Oscan titles of offices are Keltic, surely the influence of the Kelts on the early destinies of Italy deserves larger consideration at the hands of our Roman historians than it has received.

NOTES ON SOME NEW SOUTH WALES MINERALS.

(Note No. 5.)

By A. LIVERSIDGE, M.A., F.R.S., Professor of Chemistry in the University of Sydney.

[Read before the Royal Society of N.S.W., December 5, 1888.]

The following notes were illustrated by specimens of the minerals mentioned.

ANTIMONY.

Native antimony occurs in calcite with gold, blende, mispickel, &c., at the New Reform Gold Mine, Lucknow. (See Gold p. 364.)

BARKLYITE = Al_2O_3 .

The opaque more or less magenta coloured variety of ruby known as barklyite, has been sent me for identification by Mr. D. A. Porter, from New England. This had previously been found at Two Mile Flat, Cudgegong.

CASSITERITE OR TIN STONE = SnO_2 .

A very finely divided tinstone occurs in elvan at Bellandean, Tenterfield, and might easily be overlooked by miners who are only used to the ordinary appearance of tinstone as it occurs in New South Wales, since this form from its grey colour and finely divided condition is liable to escape recognition.

Associated with it are occasional scales of glistening pearly white gilbertite mica.

COBALTINE.

The sulpharsenide of cobalt CoAs_2 , CoS , found with erythrite at Carcoar, in massive lumps, with a granular structure.

COVELLINE OR INDIGO COPPER—Copper sulphide = CuS .

This mineral occurs with redruthite, the copper sub-sulphide Cu_2S and other sulphur ores of copper at Cobar and other copper mines in New South Wales.

ERYTHRITE OR COBALT BLOOM.

Hydrated arseniate of cobalt obtained by Mr. J. A. McKillop, near Carcoar, where it occurs in association with cobaltine, molybdenite &c. The erythrite is present in groups of silky radiating acicular crystals of a beautiful peach colour. Also in globular and uniform masses, and in incrustations, which present a remarkable pearly pink lustre on the freshly fractured surfaces.

It is clearly an oxidation product of the oolbaltine which accompanies it.

GAHNITE—Zinc spinel = $\text{Zn Al}_2\text{O}_4$.

The lavender coloured specimen was sent me for identification ten or twelve years ago, but without locality.

Mr. D. A. Porter also sent me a specimen of this mineral from near Tenterfield for identification in 1885, and another from Tingha in 1887, so that the mineral probably occurs in several localities.

GARNETS.

From the New England District, on the borders of Queensland, these are the ordinary red garnets (iron-alumina garnet), but like those found in Queensland have been mistaken for rubies.

The Bohemian garnet, magnesia alumina garnet, is said to occur in large quantities near Maryland Creek, Co. Buller.

GRAPHITE.

From Undercliff Station, Wilson's Downfall, New England, obtained by Mr. Wooler.

The nodules of this graphite look of very good quality when rubbed and polished, but on breaking them open they are seen to contain a good deal of earthy matter; one nodule examined for me by Dr. G. S. Mackenzie in the University Chemical Laboratory, was found to contain only 30 per cent. of carbon. Hence for most commercial purposes the graphite would require purifying before it could be used. Associated with the graphite are rolled pebbles of quartz and rock crystal.

GOLD.

Amongst the specimens forming the subject of these notes and placed before you on the table is a specimen of gold in calcite, obtained from the New Reform Gold Mine, Lucknow and sent to me by Mr. Newman as an unusual specimen.

The gold is very pale in colour and of a greenish tint, and occurs in the form of very thin films and strings, which follow the cracks in the calcite and junctions of the crystals rather than the cleavage planes of the crystals. The calcite cleaves well, is white, but shows iron stains in parts.

There are also two specimens of auriferous quartz from the celebrated early find of Gold in Louisa Creek, Turon River, obtained on the spot in 1851 by Mr. J. Alger, to whom I am indebted for the specimens. The quartz is ordinary white vein quartz with ferruginous stains and cavities apparently left by the removal of iron pyrites.

GOLD AND NATIVE ANTIMONY.

From the same mine, the New Reform Lucknow, specimens are shown of gold in calcite as the vein stuff and in association with native antimony, mispickel, zinc blende, pyrites, and silver-bearing galena.

The vein apparently runs through diorite and serpentine—some of the serpentine is of the foliated varieties known as marmolite, and in places a little asbestos is present, especially at the deeper levels. The native antimony is present in places in considerable quantity, and came in at about 350 feet.

MARMOLITE.

This foliated variety of serpentine occurs with massive serpentine on Jones' Creek, Gundagai.

MOLYBDENITE—Molybdenum sulphide = MoS_2 .

Found with cobaltine and erythrite at Carcoar in fairly well developed platy crystals.

PLATINUM, OSMIUM, AND IRIIDIUM.

The small specimen of platinum associated with gold was found on the head waters of the Bogan and Lachlan rivers, N.E. of Condobolin.

I am informed by Mr. Harding of Grafton, that gold, platinum, and osmi-iridium occur in the sea sands at Jamba, Clarence Heads, and generally in the north ends of the bays and reaches along the New South Wales coast. The "platinum" consists principally of osmium and iridium and contains only about 30% of platinum, hence it is only worth a few shillings an ounce.

PREHNITE.

This zeolite has been found in the basalt at the Prospect reservoir. Some imperfect and small crystals were also sent to me by Mr. D. A. Porter for identification, who had obtained them from serpentine in New England in 1887.

The sp. grs. of two specimens from New England were 2.89 and 2.90.

SIDERITE = FeCO_3 .

Some fairly good crystals of this mineral have been found at the Cobar Copper Mines.

PYRRHOTINE—Magnetic pyrites.

The Revd. J. Milne Curran reports the presence of this mineral at Cobar in the massive condition.

SILVER.

Leaf silver on schist from Sunny Corner.

Crystallized silver on silver chloride from Lewis Ponds.

The Revd. J. Milne Curran informs me that he has found silver in scales on redruthite at the Cobar Copper Mine.

SILVER CHLORIDE = AgCl .

From Silverton, fairly well formed branching groups of crystals.

All the New South Wales silver chloride specimens which I have examined so far, contain iodine, some only traces, but others a fair percentage.

STANNITE, TIN PYRITES.

Mr. Theodore Ranft informs me that he found this mineral in the Ottery Lode, Tent Hill, New England.

TELLURATE OF BISMUTH—MONTANITE.

The specimens were presented to me by Mr. R. Atkinson Price of Market Street, and obtained from Captain's Flat; the first specimens which came under my notice were I believe from the same place, and were shown to me for identification by Mr. C. S. Wilkinson, F.G.S., early in June last, they have since been described by Mr. Mingaye, before the Chemical Section of the Australasian Association for the Advancement of Science, Vol. i., 1888. It is reddish-brown, with dirty orange coloured mineral, soft, and very like certain stalactitic brown hæmatite, waxy centre, soft and brittle. Associated with it is tetradymite (a telluride of bismuth) and tellurium ochre.

TOPAZ.

Water worn crystals and fragments from Scrubby Gully, New England District. Some are of fair size, clear, free from flaws, and would cut very well.

EXHIBIT.

CALIFORNIAN BATEA, OR GOLD PROSPECTING DISH.—The Californian batea is a wooden dish for gold prospecting; this is much more convenient and useful than the ordinary gold prospecting tin dish, and is generally used in America in preference. It is conical in section, and all the gold and heavy minerals can readily be collected in the apex of the conical cavity, and the gold if necessary taken up by a few drops of mercury. The grains of

the wood also assists in separating the gold, since it gets rubbed up in working and then acts somewhat in the same way as the blanket used in gold washing. In size it is about 20 inches diameter and $2\frac{1}{2}$ inches deep, and being provided with a thick rim it is more convenient and less fatiguing to hold, further it does not readily break nor get knocked out of shape like the ordinary tin dish. It is now some years since examples of this dish were obtained, at my suggestion, from San Francisco for the University Collection and Technological Museum, and my reason for bringing it under your notice is that when in San Francisco in 1887, on making inquiries as to its use, I was informed that no other dish is now employed in California—in fact it is in general use in America. If the batea were known and procurable here, I have no doubt its advantages would be appreciated by Australian miners.

WEDNESDAY, DECEMBER 5, 1888.

Sir ALFRED ROBERTS, President in the Chair.

Twenty members were present.

The minutes of the last meeting were read and confirmed.

The certificates of five new candidates were read for the third time, of two for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Barling, Joseph, Under Secretary for Public Works, Sydney.

Fitzhardinge, Grantley Hyde, Balmain.

Marden, John, M.A., LL.B., *Melbne.*, Ashfield.

Smeaton, Rev. W. H. O., Rockhampton, Queensland.

White, The Hon. R. H. D., M.L.C., Sydney.

The Chairman stated that the Council recommended the election of the following gentlemen as Honorary Members of the Society viz. :—

Ralph Tate, F.G.S., F.L.S., Professor of Natural Science, Adelaide University.

Capt. Frederick Wollaston Hutton, F.G.S., Professor of Geology, Canterbury College, Christchurch, New Zealand.

The election was carried unanimously.

The Chairman announced that the Clarke Medal for 1889 had been awarded by the Council to R. L. J. Ellery, F.R.S., &c., Government Astronomer of Victoria, accompanied by the following letter :—

The Royal Society of New South Wales,
Sydney, 28th November, 1888.

To R. L. J. Ellery, Esq., F.R.S., &c.

Government Astronomer of Victoria, Melbourne.

My dear Sir,—I have the pleasure to forward to you by post, the *Clarke Memorial Medal* which has been awarded to you by the Council of the Royal Society of New South Wales, in recognition of your long continued Scientific labours, and more particularly on account of your invaluable contributions to the Astronomy and Meteorology of the Southern Hemisphere.

The Council trust that you will accept the medal as a mark also of the appreciation which is entertained for your distinguished services to the cause of Science generally.

I am, my dear Sir,

Yours very truly,

A. LIVERSIDGE, Hon. Secretary.

It was resolved that Messrs. H. O. Walker and P. N. Trebeck be appointed Auditors for the present year.

A paper was read on "The Latin verb *Jubere*—a Linguistic Study," by John Fraser, B.A., LL.D., (*Edin.*)

Professor Liversidge exhibited a large collection of New South Wales Minerals.

A series of photographs of unusually large trees growing near Sydney, taken by Dr. H. G. A. Wright and presented by him to the Society, were also exhibited.

The thanks of the Society were accorded to the several gentlemen for the valuable paper and exhibits.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF NOVEMBER, 1888.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

ADELAIDE—Public Library, Museum, and Art Gallery of South Australia. Report of the Board of Governors for 1887-8.

The Board.

AREZZO—Regia Accademia Petrarca di Scienze, Lettere ed Arti. Statuti.

The Academy.

BERNE—Département Fédéral de l'Intérieur. Section des Travaux Publics. Tableau graphique des observations hydrométriques suisses. Pl. 1, 1a, 1b, 2, 2a, 2b, 3, 4, 5, 6; 1887. Graphische Darstellung der Schweizerischen hydrometrischen Beobachtungen. Bl. 1a, 1b, 2a, 2b, 2c, 3, 4, 5a, 5b, 6.

The Department.

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(Names of Donors are in *Italics*.)

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PROCEEDINGS OF THE SECTIONS

(IN ABSTRACT.)

MEDICAL SECTION.

The preliminary meeting for the election of officers was held April 13th, 1888, and the result of the ballot was as follows:—
 Chairman: Dr. S. T. KNAGGS. Secretaries: A. MACCORMICK, M.D., EDWD. J. JENKINS, M.D. Committee: Drs. W. CHISHOLM, CRAIGO, FAIRFAX ROSS, SYDNEY JONES, HANKINS, and GOODE.

Seven general meetings were held during the session, and the attendance was above the usual average.

Papers were read by—

- Dr. MACCORMICK on "Excision of the Thyroid."
- Dr. GOODE, on "two cases of fracture of the skull-trephining; Recovery."
- Dr. WORRALL, on "Induction of Labour."
- Dr. ROTH, on "Rational Infant's Clothing."
- Dr. JENKINS, on "Splenic Leucocythaemia."
- Dr. GRAHAM, on "Exophthalmic goitre."
- Dr. FAITHFUL, on "The treatment of Migraine."
- Dr. MACCORMICK, on "The Radical Cure of Hernia."
- Dr. JENKINS, on "Intrathoracic Tumours."
- Dr. SHEWIN, on cases of "Gangrene and abscess of the Lung."

A special evening was set apart for the discussion of the recent treatment of Typhoid Fever. The subject was opened by Dr. JENKINS, and a paper was read also by Dr. CARRUTHERS on "The Diagnosis of Typhoid Fever." The discussion was continued by Sir ALFRED ROBERTS, Drs. FAIRFAX ROSS, KNAGGS, CRAIG, McCULLOCH, MURRAY ORAM, and Dr. MACLAURIN.

The following exhibits were made:—

- Dr. WORRALL—Two fibroid tumours of the uterus, and a degenerated ovum.
- Dr. GOODE—A patient from whom he had removed the whole of the left necrosed tibia, and new bone had been formed from the periosteum which had been left.
- Dr. MACCORMICK—A patient with ununited fracture of the left humerus.
- Dr. JENKINS—A patient with "aortic regurgitation, Aneurism of the arch of the aorta and obliteration of the left carotid artery."
- Dr. ROTH—A "scoliometer."
- Dr. QUAIFF, Jun.—A nasal polypus and laryngeal growth.
- Dr. FAIRFAX ROSS—"A patient for diagnosis," with exophthalmia of the left eye and no loss of vision or anything definite to account for peculiar symptoms.
- Dr. GRAHAM—A man with "Exophthalmic goitre."

Dr. JENKINS—A heart showing aneurism of arch of aorta, and obliteration of the lumen of left carotid artery.

A. MACCORMICK, M.D. }
E. J. JENKINS, M.D. ... } Secretaries.

S. T. KNAGGS, M.D., Chairman.

MICROSCOPICAL SECTION.

A preliminary meeting of this Section was held on April 8th. 1888; Mr. G. D. HIRST occupied the Chair. Mr. F. B. KYNGDON was re-elected as Chairman for the present year; Mr. PERCY J. EDMUNDS as Secretary; and Dr. H. G. A. WRIGHT, Dr. MORRIS, Mr. S. MACDONNELL, and Mr. H. O. WALKER were elected members of the Committee.

Monthly Meeting held MAY 14th, 1888.

Mr. F. B. KYNGDON in the Chair.

Dr. WRIGHT exhibited some very excellent micro-photographs of various objects (diatoms, podura-scales, tongues of insects &c.) taken with Zeiss's 1 inch, Tolles' $\frac{1}{4}$ th and Zeiss's apochromatic $\frac{1}{4}$ th, some by means of lamplight, others by the incandescent electric light.

Dr. WRIGHT also exhibited a monocular microscope by E. Leitz of Wetzlow. The $\frac{1}{8}$ th oil-immersion lens belonging to it was tested with success on slides of *Navicula angulatum* and *Amph. pellucida*.

Mr. PEDLEY exhibited an indurated tumour from a pig's cheek.

Monthly Meeting held JUNE 11th, 1888.

Mr. F. B. KYNGDON in the Chair.

Dr. WRIGHT exhibited some micro-photographs similar to those shown at last meeting.

Mr. MACDONNELL exhibited two species of *Caprellæ* with numerous diatoms firmly attached.

Dr. SINCLAIR exhibited a new model of microscope by Zeiss with Abbe's condenser.

Mr. EDMUNDS exhibited the original immersion paraboloid invented by Dr. James Edmunds, of London. Also several forms of micrometer and other eye-pieces.

Monthly Meeting held JULY 9th, 1888.

Mr. F. B. KYNGDON in the Chair.

On the suggestion of Mr. G. D. Hirst, it was decided that application should be made to the Council to purchase a low-power objective of two or three inches focus.

Mr. PEDLEY exhibited some photographs of *Pleurosigma formosum* which seemed by their appearance at the broken edges to support the "bead" theory.

Dr. WRIGHT presented about twenty copies of the micro-photographs lately taken by him.

Mr. MACDONNELL exhibited the larva of the fresh-water Marsh-fly encrusted with short-stemmed living *Vorticella*. This object was illuminated with the parabolic illuminator.

Mr. WHITELEGGE exhibited slides showing a species of coral (*Clavulina*), a Zoophyte (*Sarsia*) and an embryo star-fish (*Asterina exigua*), all obtained from the waters of Port Jackson.

The Rev. ROBERT COLLIE exhibited three specimens of moss mounted in balsam, and obtained from Mossman's Bay.

Monthly Meeting held AUGUST 13th, 1888.

Mr. F. B. KYNGDON in the Chair.

Mr. WALKER showed some living specimens of *Rotatoria* (*Lacinularia socialis*) obtained from Parramatta River.

Mr. MACDONNELL exhibited specimens of the "brick-building" Rotifer, *Melicerta ringens*, in full activity.

Mr. WHITELEGGE exhibited Gorgona spicules (*Mopsella coccinea*) found at Watson's Bay.

Dr. WRIGHT exhibited some micro-photographs showing enlargements of 5500 diameters.

Mr. HURST exhibited a species of *Vorticella*.

Mr. EDMUNDS exhibited some foraminifera illuminated by the immersion paraboloid.

Monthly Meeting held SEPTEMBER 3rd, 1888.

Mr. F. B. KYNGDON in the Chair.

Mr. TRYON, from Queensland, furnished some interesting information concerning investigations lately carried on by him relative to the recently discovered parasite harboured in rat's blood. It was found to be a monad with definite nucleus and limiting membrane. It was probably identical with the parasite supposed

to cause the disease known in India as "Surrah" in horses and cattle, and perhaps also with that causing malarial fever in man.

Mr. MACDONNELL exhibited some of Mr. Sharp's (of Adelong) beautiful entomological slides.

Mr. WHITELEGGE exhibited the calcareous wheel-plates of Chirodota and several other Rotifer slides, these organisms being killed with their coronæ fully extended.

Mr. EDMUNDS exhibited a small Nachet microscope.

Monthly Meeting held OCTOBER 15th, 1888.

Mr. F. B. KYNGDON in the Chair.

Mr. WIESENER exhibited five new models of microscopes made by Anderson of London. Also a $2\frac{1}{2}$ inch objective made in his establishment, (being the first objective made in the colony,) and which he presented to the Society.

Mr. MACDONNELL read a communication from Mr. E. Bostock of Stone, England, asking for co-operation in investigating the Oribatidæ, or beetle-mites.

Monthly Meeting held NOVEMBER 12th, 1888.

Mr. F. B. KYNGDON in the Chair.

Mr. WHITELEGGE exhibited a slide showing embryo starfish, and fully described the development of the Australian form *Asterina exigua*.

Mr. KYNGDON exhibited a brownish reticulated mass found in an old wooden house, and recognized as the excreta of white ants. Also some curiously punctured gall-nuts or gum-leaves.

PERCY J. EDMUNDS, Hon. Sec.

ADDITIONS
TO THE
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* Exchanges of Publications have been received from the Societies and Institutions distinguished by an asterisk.

Argentine Republic.

- 1 CORDOBA ... *Academia Nacional de Ciencias.

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- 2 PRAGUE ... *Königlich böhmische Gesellschaft der Wissenschaften.
3 TRIESTE ... *Società Adriatica di Scienze Naturali.
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7 " ... *K. K. Geographische Gesellschaft.
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9 " ... *K. K. Naturhistorische Hofmuseum.
10 " ... *K. K. Zoologisch-Botanische Gesellschaft.

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- 11 BRUSSELS... *Académie Royale des Sciences, des Lettres et des Beaux Arts.
12 " ... *Musée Royal D'Histoire Naturelle de Belgique.
13 " ... *Observatoire Royal de Bruxelles.
14 " ... *Société Royale Malacologique de Belgique.
15 LIEGE ... *Société Géologique de Belgique.
16 " ... *Société Royale des Sciences de Liège.
17 LUXEMBOURG *Institut Royale grand-ducal de Luxembourg.
18 MONS ... *Société des Sciences, des Arts et des Lettres du Hainaut.

Brazil.

- 19 RIO DE JANEIRO... *L'Observatoire Impérial de Rio de Janeiro.

Chili.

- 20 SANTIAGO ... *Sociedad Científica Alemana.

EXCHANGES AND PRESENTATIONS.

Denmark.

- 21 COPENHAGEN ... *Société Royale des Antiquaires du Nord.

France.

- 22 BORDEAUX ... *Académie Nationale des Sciences, Belles-Lettres et Arts.
 23 CAEN ... *Académie Nationale des Sciences, Arts et Belles-Lettres.
 24 DIJON ... *Académie des Sciences, Arts et Belles-Lettres.
 25 LILLE ... *Société Géologique du Nord.
 26 MONTPELLIER ... *Académie des Sciences et Lettres.
 27 PARIS ... *Académie des Sciences de l'Institut de France.
 28 " ... *Dépôt des Cartes et Plans de la Marine.
 29 " ... Ecole Nationale des Mines.
 30 " ... Ecole Normale Supérieure.
 31 " ... *Ecole Polytechnique.
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 41 " ... Société de Chirurgie de Paris.
 42 " ... *Société d'Encouragement pour l'Industrie Nationale.
 43 " ... *Société de Géographie.
 44 " ... *Société Entomologique de France.
 45 " ... *Société Géologique de France.
 46 " ... Société Météorologique de France.
 47 " ... *Société Française de Minéralogie.
 48 " ... *Société Française de Physique.
 49 " ... *Société Philotechnique.
 50 " ... *Société Zoologique de France.
 51 SAINT ETIENNE ... *Société de l'Industrie Minérale.
 52 TOULOUSE ... *Académie des Sciences Inscriptions et Belles-Lettres.

Germany.

- 53 BREMEN ... *Naturwissenschaftlicher Verein zu Bremen.
 54 BERLIN ... Deutsche Chemische Gesellschaft.
 55 " ... *Königlich Preussische Akademie der Wissenschaften.
 56 " ... *Königl. Preuss. Meteorologisches Institut.
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 60 " ... *Naturwissenschaftlicher Verein zu Karlsruhe.
 61 CASSEL ... *Verein für Naturkunde.
 62 CHEMNITZ ... *Naturwissenschaftliche Gesellschaft zu Chemnitz.
 63 DRESDEN ... *Das Statistische Bureau des Ministeriums des Innern zu Dresden.

EXCHANGES AND PRESENTATIONS.

64	DRESDEN ...	... *Königliches Mineralogische Museum.
65	„ ...	... *Öffentliche Bibliothek.
66	„ ...	... *Verein für Erdkunde zu Dresden.
67	ELBERFELD ...	... *Naturwissenschaftlicher Verein in Elberfeld.
68	FRANKFURT a/M...	... *Senckenbergische Naturforschende Gesellschaft Frankfurt a/M.
69	FREIBERG(Saxony)	Die Berg Akademie zu Freiberg.
70	„ ...	... *Naturforschende Gesellschaft zu Freiberg.
71	GÖRLITZ ...	... *Naturforschende Gesellschaft in Görlitz.
72	GÖTTINGEN ...	... *Königliche Gesellschaft der Wissenschaften in Göttingen.
73	HALLE, A.S. ...	... *Die Kaiserlich Deutsche Leopoldinisch—Caroli- nische Akademie der Naturforcher zu Halle A.S. (Prussia).
74	HAMBURG...	... *Deutsche Meteorologische Gesellschaft.
75	„ ...	... *Deutsche Seewarte.
76	„ ...	... *Die Geographische Gesellschaft in Hamburg.
77	„ ...	... *Naturhistorisches Museum der freien Stadt Hamburg.
78	„ ...	... *Verein für Naturwissenschaftliche Unterhaltung in Hamburg.
79	HEIDELBERG ...	... *Naturhistorisch Medicinischer Verein zu Heidelberg.
80	JENA ...	... *Medicinisch Naturwissenschaftliche Gesellschaft.
81	KÖNIGSBERG ...	... *Königliche Physikalisch-ökonomische Gesell- schaft.
82	LEIPZIG (Saxony)	*Königliche Sächsische Gesellschaft der Wissen- schaften.
83	„ ...	... *Vereins für Erdkunde.
84	MARBURG...	... *Gesellschaft zur Beförderung der gesammten Naturwissenschaften in Marburg.
85	„ ...	... *The University.
86	METZ ...	... *Verein für Erdkunde zu Metz.
87	MULHOUSE ...	... *Société Industrielle de Mulhouse.
88	MÜNCHEN...	... *Königlich Baiерische Akademie der Wissen- schaften in München.
89	STUTTGART ...	... *Königliches Statistisches Landesamt.
90	„ ...	... *Verein für Vaterländische Naturkunde in Württemberg.

Great Britain and the Colonies.

91	BIRMINGHAM ...	... *Birmingham and Midland Institute.
92	„ ...	... *Birmingham Philosophical Society.
93	BRISTOL ...	... *Bristol Naturalists' Society.
94	CAMBORNE ...	... *Mining Association and Institute of Cornwall.
95	CAMBRIDGE ...	... *Philosophical Society.
96	„ ...	... *Public Free Library.
97	„ ...	... Union Society.
98	„ ...	... University Library.
99	LEEDS ...	... *Conchological Society.
100	„ ...	... *Philosophical and Literary Society.
101	„ ...	... *Yorkshire College.
102	LIVERPOOL ...	... *Literary and Philosophical Society.
103	LONDON ...	... *Agent-General (two copies).
104	„ ...	... *Anthropological Institute of Great Britain and Ireland.

EXCHANGES AND PRESENTATIONS.

106	LONDON	...	*British Museum (two copies).
106	"	...	Chemical Society.
107	"	...	Colonial Office, Downing Street.
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111	"	...	*Institution of Naval Architects.
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113	"	...	Library, South Kensington Museum.
114	"	...	*Linnean Society.
115	"	...	London Institution.
116	"	...	*Lords Commissioners of the Admiralty.
117	"	...	*Lord Lindsay's Observatory.
118	"	...	*Meteorological Office.
119	"	...	*Mineralogical Society.
120	"	...	Museum of Practical Geology.
121	"	...	Patent Office Library.
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123	"	...	*Physical Society, South Kensington Museum.
124	"	...	*Quekett Microscopical Club.
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126	"	...	*Royal Asiatic Society of Great Britain and Ireland.
127	"	...	*Royal Astronomical Society.
128	"	...	*Royal College of Physicians.
129	"	...	*Royal College of Surgeons.
130	"	...	*Royal Colonial Institute.
131	"	...	*Royal Geographical Society.
132	"	...	*Royal Historical Society.
133	"	...	*Royal Institution of Great Britain.
134	"	...	*Royal Meteorological Society.
135	"	...	*Royal Microscopical Society.
136	"	...	Royal School of Mines.
137	"	...	*Royal Society.
138	"	...	Royal Society of Literature.
139	"	...	*Royal United Service Institution.
140	"	...	Society of Arts.
141	"	...	University of London.
142	"	...	War Office—(Intelligence Division).
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149	"	...	*Society of Chemical Industry.
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151	"	...	*Bodleian Library.
152	"	...	*Radcliffe Library.
153	"	...	*Radcliffe Observatory.
154	PENZANCE	...	*Royal Geological Society of Cornwall.
155	PLYMOUTH	...	*Plymouth Institution and Devon and Cornwall Natural History Society.
156	WINDSOR	...	The Queen's Library.

EXCHANGES AND PRESENTATIONS.

CAPE OF GOOD HOPE.

- 157 CAPE TOWN ... *South-African Philosophical Society.

DOMINION OF CANADA.

- 158 HALIFAX (NOVA SCOTIA) } *Nova Scotia Institute of Natural Science.
 159 HAMILTON (Canada West) } *Hamilton Association.
 160 MONTREAL ... *Natural History Society of Montreal.
 161 OTTAWA ... *Geological and Natural History Survey of Canada.
 162 " ... *Royal Society of Canada.
 163 " ... The Ottawa Literary and Scientific Society.
 164 TORONTO... *Canadian Institute.
 165 WINNIPEG ... *Manitoba Historical and Scientific Society.

INDIA.

- 166 CALCUTTA ... *Asiatic Society of Bengal.
 167 " ... *Geological Survey of India.

IRELAND.

- 168 DUBLIN ... *Royal Dublin Society.
 169 " ... *Royal Geological Society of Ireland.
 170 " ... *Royal Irish Academy.

MAURITIUS.

- 171 PORT LOUIS ... Royal Society of Arts and Sciences.
 172 " ... Société d'Acclimatation de l' Ile Maurice.

NEW SOUTH WALES.

- 173 SYDNEY ... *Australian Museum.
 174 " ... *Engineering Association of New South Wales.
 175 " ... *Free Public Library.
 176 " ... *Linnean Society of New South Wales.
 177 " ... *Mining Department.
 178 " ... *Observatory.
 179 " ... School of Arts.
 180 " ... *Technological Museum.
 181 " ... *University.

NEW ZEALAND.

- 182 AUCKLAND ... *Auckland Institute.
 183 CHRISTCHURCH ... Philosophical Institute of Canterbury.
 184 DUNEDIN ... Otago Institute.
 185 WELLINGTON ... *Colonial Museum.
 186 " ... *New Zealand Institute.

QUEENSLAND.

- 187 BRISBANE ... *Acclimatization Society of Queensland.
 188 " ... *Royal Geographical Society of Australasia (Queensland Branch).
 189 " ... Parliamentary Library.
 190 " ... *Royal Society of Queensland.

SCOTLAND.

- 191 ABERDEEN ... *Dun Echt Observatory, Earl of Crawford and Balcarres.
 192 " ... *University.

EXCHANGES AND PRESENTATIONS.

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196	"	...	*Royal Observatory.
197	"	...	*Royal Physical Society.
198	"	...	*Royal Society.
199	"	...	*Scottish Geographical Society.
200	"	...	*University.
201	GLASGOW	...	*Geological Society of Glasgow.
202	"	...	*University.

SOUTH AUSTRALIA.

203	ADELAIDE	...	*Government Botanist.
204	"	...	*Government Printer.
205	"	...	*Observatory.
206	"	...	*Royal Society of South Australia.
207	"	...	*Public Library, Museum and Art Gallery of South Australia.
208	"	...	*University.

STRAITS SETTLEMENTS.

209	SINGAPORE	...	*Royal Asiatic Society.
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TASMANIA.

210	HOBART	...	*Royal Society of Tasmania.
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VICTORIA.

211	BALLAARAT	...	*School of Mines and Industries.
212	MELBOURNE	...	*Field Naturalists' Club of Victoria.
213	"	...	*Government Botanist.
214	"	...	*Government Statist.
215	"	...	*Mining Department.
216	"	...	*Observatory.
217	"	...	*Public Library.
218	"	...	*Registrar-General.
219	"	...	*Royal Society of Victoria.
220	"	...	*University.
221	"	...	*Victorian Institute of Surveyors.

Hayti.

222	PORT-AU-PRINCE	Société de Sciences et de Géographie.
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Hungary.

223	BISTRITZ (in Siebenbürgen)	} *Direction der Gewerbeschule.
224	ZAGREB (Agram)	
		*Société Archéologique.

Italy.

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226	"	...	Università di Bologna.
227	FLORENCE	...	*Società Entomologica Italiana.
228	"	...	*Società Italiana di Antropologia e di Etnologia.
229	"	...	*Società Africana d' Italia (Sezione Fiorentina).
230	GENOA	...	*Museo Civico di Storia Naturale.

EXCHANGES AND PRESENTATIONS.

231	MILAN	...	Reale Istituto Lombardo di Scienze Lettere ed Arti.
232	"	...	Società Italiana di Scienze Naturali.
233	MODENA	...	*Académie Royale de Sciences, Lettres et Arts de Modène.
234	NAPLES	...	*Società Africana d'Italia.
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236	"	...	*Stazione Zoologica (Dr. Dohrn).
237	PALESTRO	...	*Accademia Palermitana di Scienze Lettere ed Arti.
238	"	...	Reale Istituto Tecnico.
239	PISA	...	*Società Toscana di Scienze Naturali.
240	ROME	...	*Accademia Pontificia de 'Nuovi Lincei.
241	"	...	*Biblioteca e Archivio Tecnico (Ministero dei Lavori Pubblici).
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243	"	...	Osservatorio del Astronomico Collegio Romano.
244	"	...	*R. Accademia dei Lincei.
245	"	...	*R. Comitato Geologico Italiano.
246	"	...	*Società Geografica Italiana.
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248	TURIN	...	Reale Accademia delle Scienze.
249	"	...	Regio Osservatorio Astronomico dell' Università.
250	VENICE	...	*Reale Istituto Veneto di Scienze, Lettere ed Arti.

Japan.

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252	"	...	*Seismological Society.
253	YOKOHAMA	...	*Asiatic Society of Japan.

Java.

254	BATAVIA	...	*Kon. Natuurkundige Vereeniging in Nederl Indië.
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Mexico.

255	MEXICO	...	*Sociedad Científica "Antonio Alzate."
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Netherlands.

256	AMSTERDAM	...	*Académie Royale des Sciences.
257	"	...	*Association Coloniale Néerlandaise.
258	"	...	*Société Royale de Zoologie.
259	HARLEM	...	*Bibliothèque de Musée Teyler.
260	"	...	*Société Hollandaise des Sciences.

Norway.

261	BERGEN	...	*Museum.
262	CHRISTIANIA	...	*Kongelige Norske Fredericks Universitet.
263	"	...	*Videnskabs-Selskabet i Christiania.

Roumania.

264	BUCHAREST	...	*Institutul Meteorologic al României.
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Russia.

265	HELSINGFORS	...	*Société des Sciences de Finlande.
266	KIEFF	...	*Société des Naturalistes.
267	MOSCOW	...	*Société Impériale des Naturalistes.

EXCHANGES AND PRESENTATIONS.

- 268 MOSCOW ... *Société Impériale des Amis des Sciences Naturelles d'Anthropologie et d'Ethnographie à Moscow (Section d'Anthropologie).
 269 ST. PETERSBURGH *Académie Impériale des Sciences.
 270 „ ... *Comité Géologique—Institut des Mines.

Spain.

- 271 MADRID ... Instituto geográfico y Estadístico.

Sweden.

- 272 STOCKHOLM ... *Kongliga Svenska Vetenskaps-Akademien.
 273 „ ... *Kongliga Universitetet.

Switzerland.

- 274 BERNE ... *Société de Géographie de Berne.
 275 GENEVA ... *Institut National Genèveois.
 276 LAUSANNE ... *Société Vaudoise des Sciences Naturelles.
 277 NEUCHÂTEL ... *Société des Sciences Naturelles.

United States of America.

- 278 ALBANY ... *New York State Library, Albany.
 279 ANNAPOLIS (MD.) *Naval Academy.
 280 BALTIMORE ... *Johns Hopkins University.
 281 BELOIT (Wis.) ... *Chief Geologist.
 282 BOSTON ... *American Academy of Arts and Sciences.
 283 „ ... *Boston Society of Natural History.
 284 BROOKVILLE ... *Brookville Society of Natural History.
 285 „ ... Indiana Academy of Science.
 286 BUFFALO ... *Buffalo Society of Natural Sciences.
 287 CAMBRIDGE ... *Cambridge Entomological Club.
 288 „ ... *Museum of Comparative Zoology, Harvard College.
 289 CHICAGO ... Academy of Sciences.
 290 CINCINNATI ... *Cincinnati Society of Natural History.
 291 COLDWATER ... Michigan Library Association.
 292 DAVENPORT (Iowa) *Academy of Natural Sciences.
 293 DENVER ... *Colorado Scientific Society.
 294 HOBOKEN (N.J.) ... *Steven's Institute of Technology.
 295 IOWA CITY (Iowa) *Director Iowa Weather Service.
 296 MINNEAPOLIS ... *Minnesota Academy of Natural Sciences.
 297 NEWHAVEN (Conn) *Connecticut Academy of Arts.
 298 NEW YORK ... *American Chemical Society.
 299 „ ... *American Geographical Society.
 300 „ ... *Editor *Journal of Comparative Medicine and Surgery*.
 301 „ ... *Editors *Science*.
 302 „ ... *New York Academy of Sciences.
 303 „ ... *New York Microscopical Society.
 304 „ ... *School of Mines, Columbia College.
 305 PHILADELPHIA ... *Academy of Natural Science.
 306 „ ... *American Entomological Society.
 307 „ ... *American Philosophical Society.
 308 „ ... *Franklin Institute.
 309 „ ... *Second Geological Survey of Pennsylvania.
 310 „ ... *Wagner Free Institute of Science.
 311 „ ... *Zoological Society of Philadelphia.

EXCHANGES AND PRESENTATIONS.

312	SALEM (Mass.)	...	*American Association for the Advancement of Science.
313	"	...	*Essex Institute.
314	"	...	*Peabody Academy of Sciences.
315	ST. LOUIS	...	*Academy of Science.
316	SAN FRANCISCO	...	*California Academy of Sciences.
317	"	...	*California State Mining Bureau.
318	WASHINGTON	...	*American Medical Association.
319	"	...	*Bureau of Education (Department of the Interior)
320	"	...	*Bureau of Ethnology.
321	"	...	*Chief of Engineers (War Department).
322	"	...	*Chief Signal Officer (War Department).
323	"	...	*Commissioner of Agriculture.
324	"	...	*Director of the Mint (Treasury Department).
325	"	...	Library (Navy Department).
326	"	...	*National Academy of Sciences.
327	"	...	*Office of Indian Affairs (Department of the Interior).
328	"	...	*Ordnance Department.
329	"	...	*Philosophical Society.
330	"	...	*Secretary (Department of the Interior).
331	"	...	*Secretary (Treasury Department).
332	"	...	*Smithsonian Institution.
333	"	...	*Surgeon General (U.S. Army).
334	"	...	*U. S. Coast and Geodetic Survey (Treasury Department).
335	"	...	*U.S. Geological Survey.
336	"	...	*U. S. National Museum (Department of the Interior).
337	"	...	U. S. Patent Office.
338	"	...	*War Department.

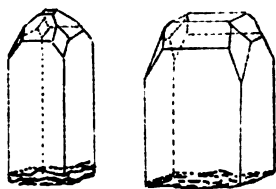
Number of Publications sent to	Great Britain	...	...	80
"	"	India and the Colonies	...	50
"	"	America	...	64
"	"	Europe	...	137
"	"	Asia, &c.	...	4
"	"	Editors of Periodicals	...	3
Total				338

A. LIVERSIDGE .. }
F. B. KYNGDON .. } Hon. Secretaries.
S. HERBERT COX }

The Society's House, Sydney, 18th April, 1888.

Mineral Localities in N.S.W. By D. A. Porter. 6th June.

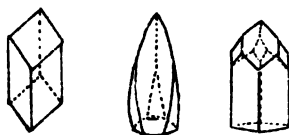
1. 2. ZIRCON x 3.



1

2

3. 4. 5. CALCITE N.S.



3

4

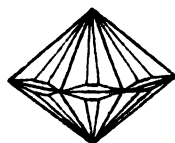
5

6. CHABAZITE N.S.

7. PHACOLITE x 2.



6



7



13

8. 9. BEYRL x 3.

13. MOLYBDENITE N.S.



8

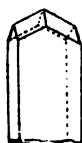


9



14

14. ZIRCON x 6.



10



11



12

10. STILBITE x 12.

11. LAUMONITE x 12.

12. VESUVIANITE x 30.

THE CUBIC PARABOLA AS APPLIED FOR EASING RAILWAY CURVES

FIG. I.

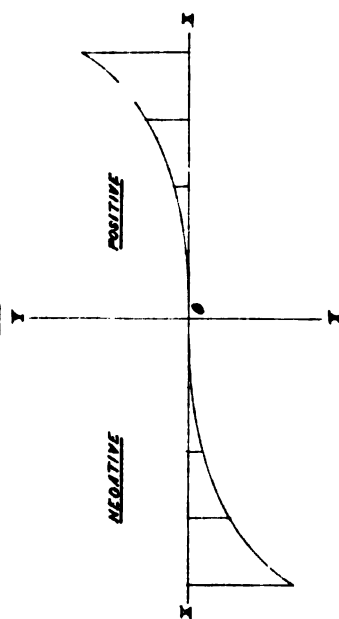


FIG. II.

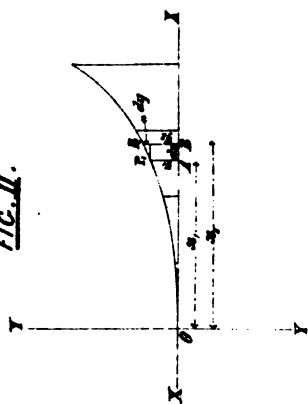


FIG. III.



FIG. IV.

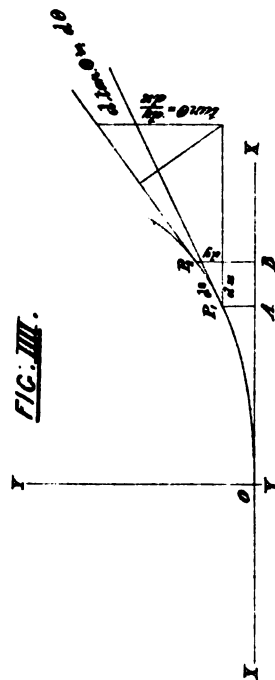
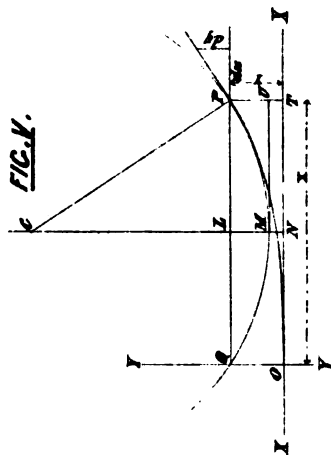


FIG. V.



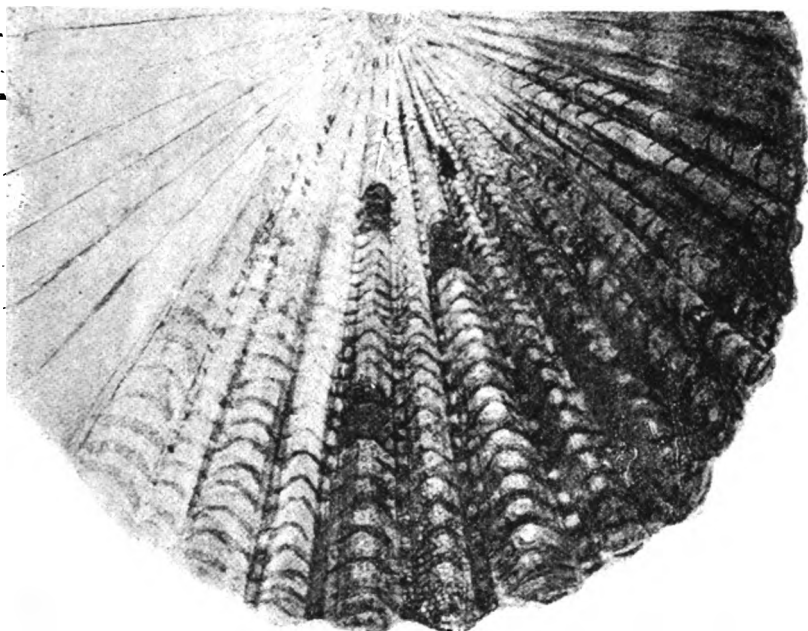


Fig. 1. *Patella tramoserica*, Martyn (enlarged) showing shell-eyes on portion of ribs, $\times 8$ diam.

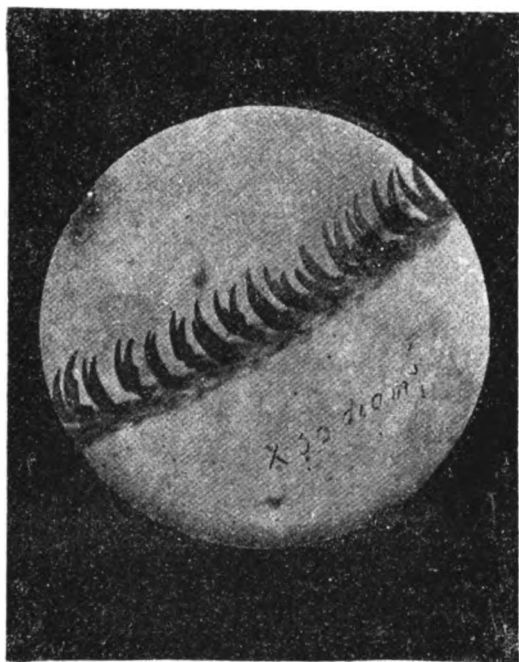


Fig. 2. Portion of Radula. *Patella tramoserica*, $\times 50$ diam.

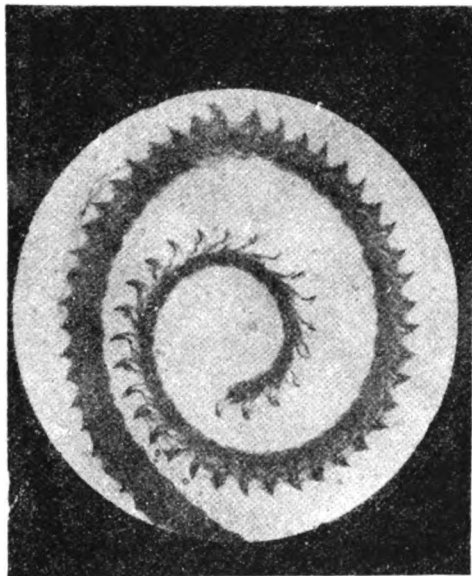


Fig. 3. Portion of Radula of *Acmæa septiformis*, $\times 50$ diam.

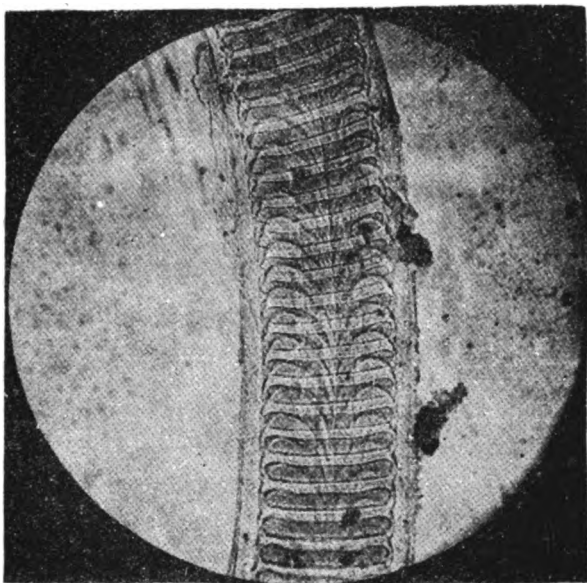


Fig. 4. Part of Radula of *Cerithium ebeninum*, Brug. $\times 75$ diam.

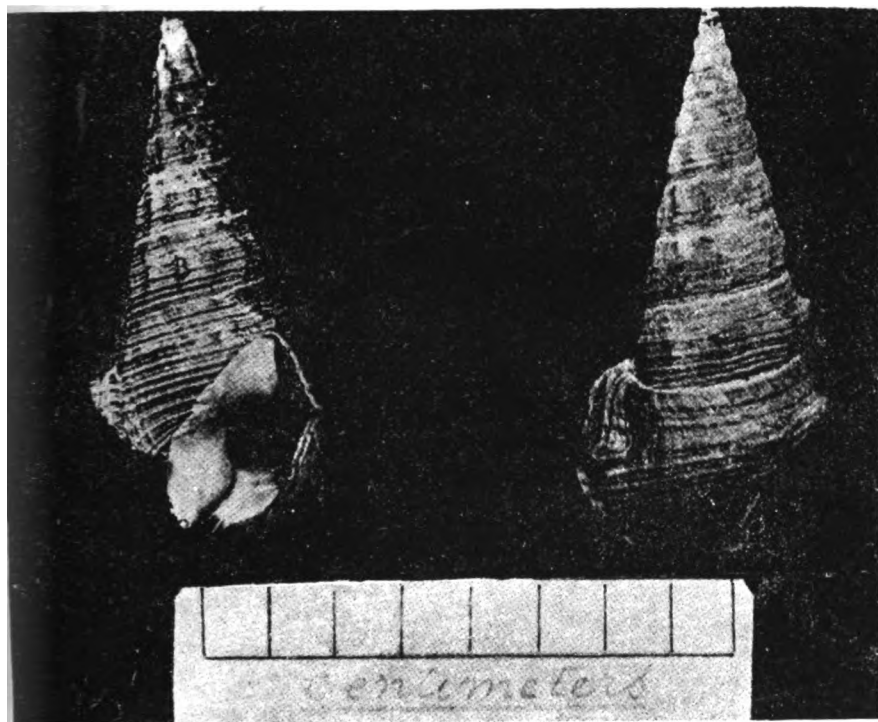


Fig. 5. *Cerithium ebeninum*. Natural size.

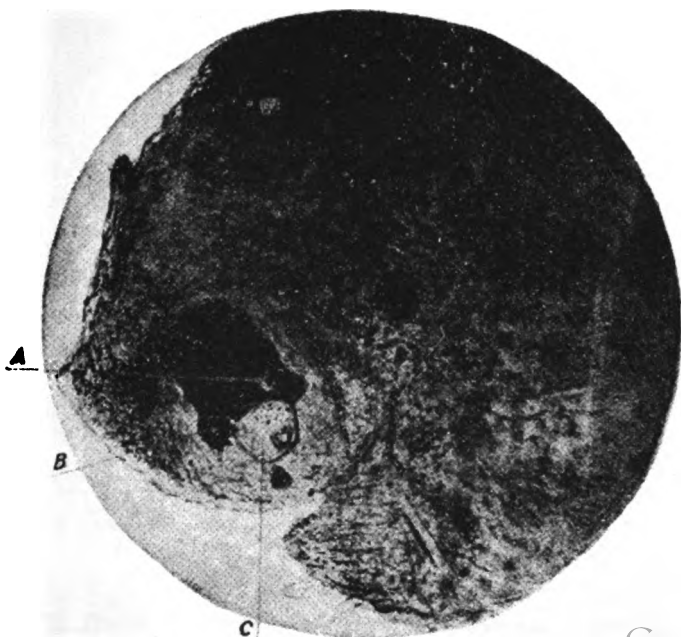


Fig. 6. Tentacle eye of *Cerithium ebeninum*, $\times 10$ diam.

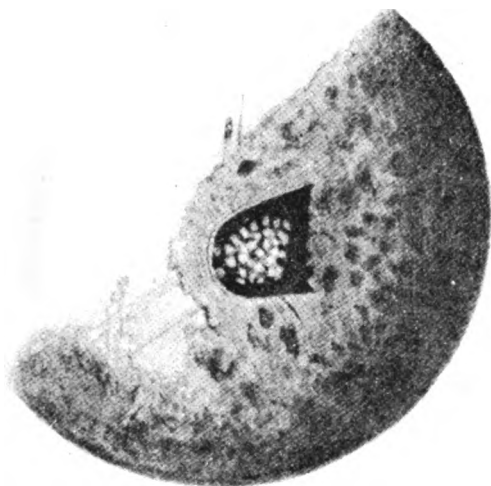


Fig. 7. Facetted tentacle eye of *Cerithium ebenerum*, $\times 10$ diam.

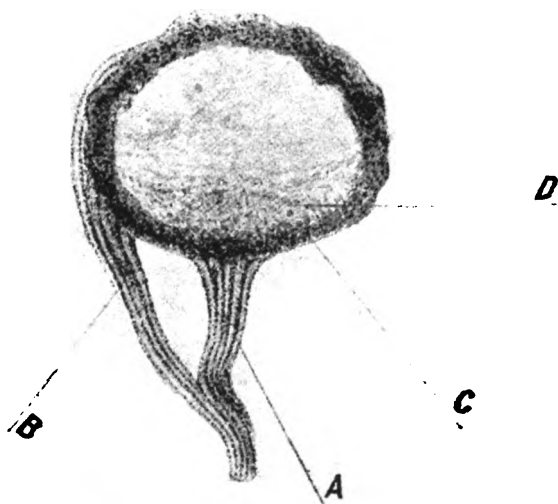


Fig. 8. Shell-eye of *Patella tramoserica*. from peristome, $\times 100$ diam.

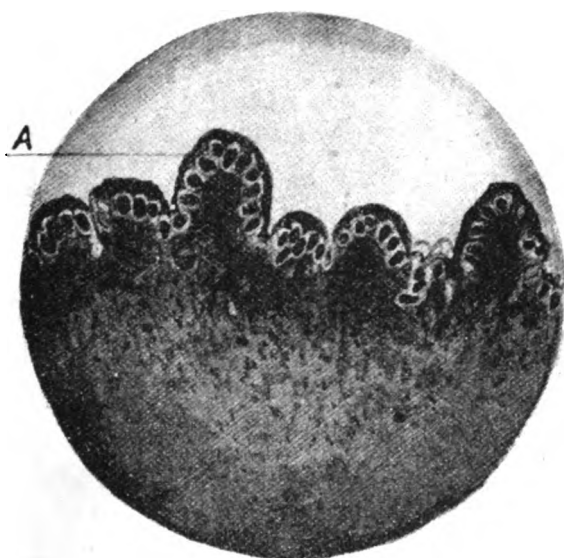


Fig. 9. Dorsal mantle of *Onchidium dānelii*, showing partial secretion of shell material, $\times 50$ dia

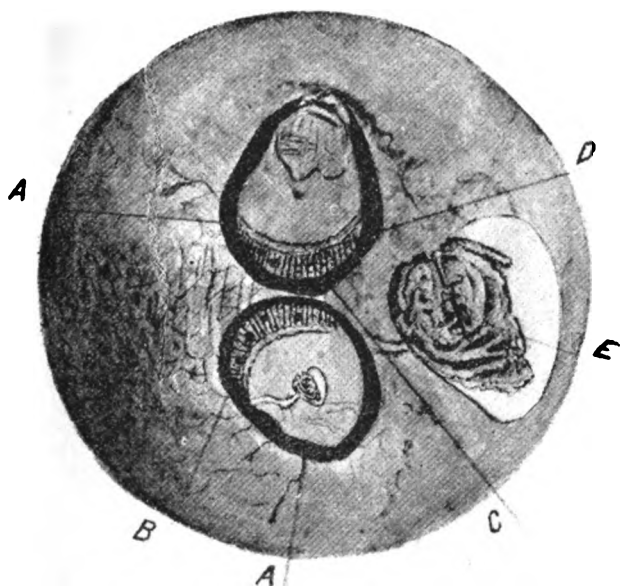


Fig. 10. Double eye of *Onchidium dānelii*, showing structure, $\times 100$ diam.

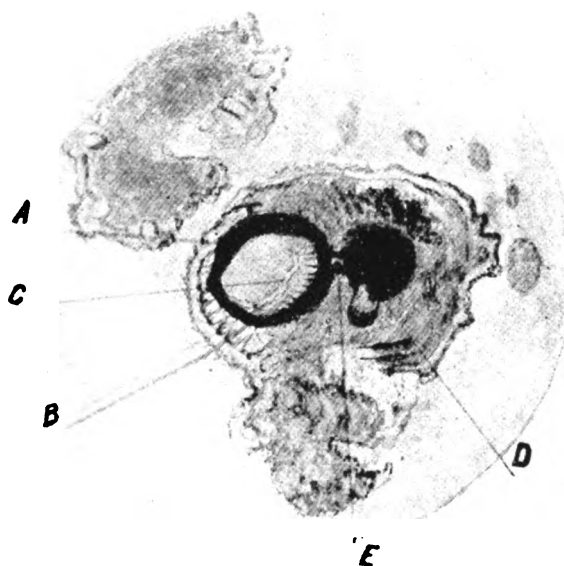


Fig. 11. Double eye *Onchidium dāmelii*, $\times 100$ diam.

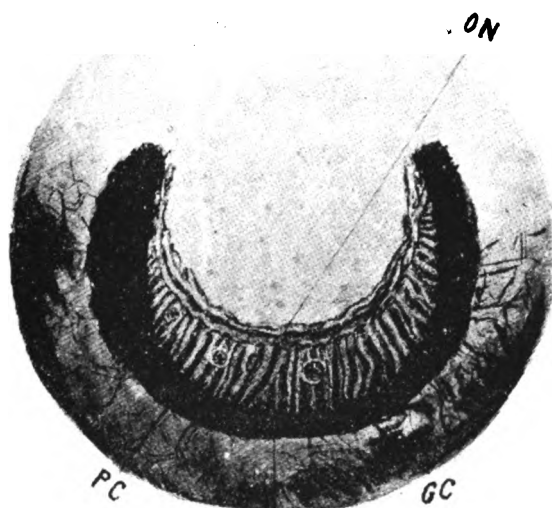


Fig. 12. Dorsal eye of *Onchidium dāmelii*, $\times 200$ diam.

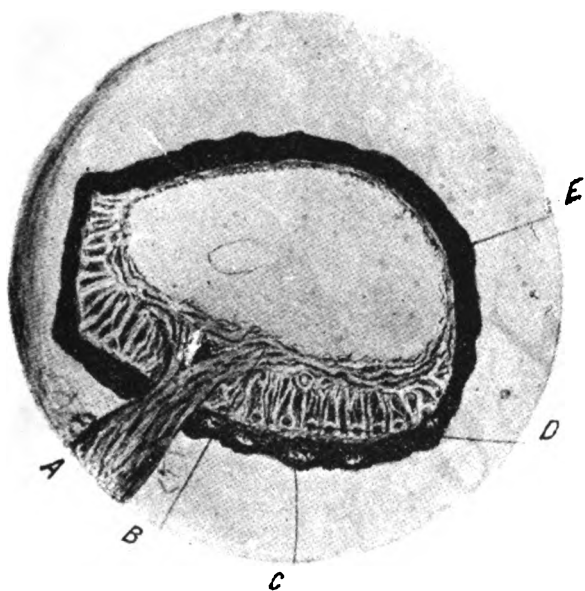


Fig. 13. Dorsal eye of *Onchidium dāmelii*, showing entry of optic nerve, $\times 150$ diam.

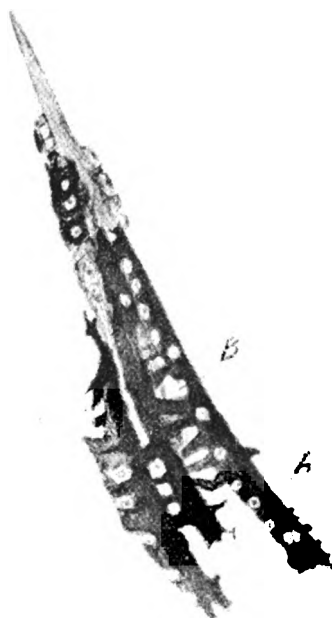


Fig. 14. Portion of Basilar membrane of dorsal eye *Onchidium dāmelii*, $\times 400$ diam.



Fig. 15. Section of eye of embryo *Octopus* in egg.

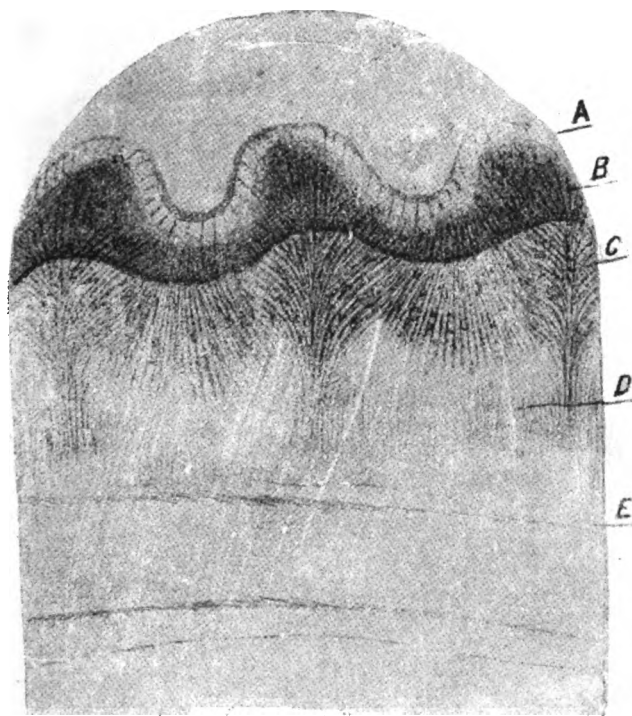


Fig. 16. Section of three ribs, *Trigonostoma lamarchii*.



Fig. 17. Nerve-ganglion or mass of nervous matter in nacreous layer of *Trigonia lamarchii*.

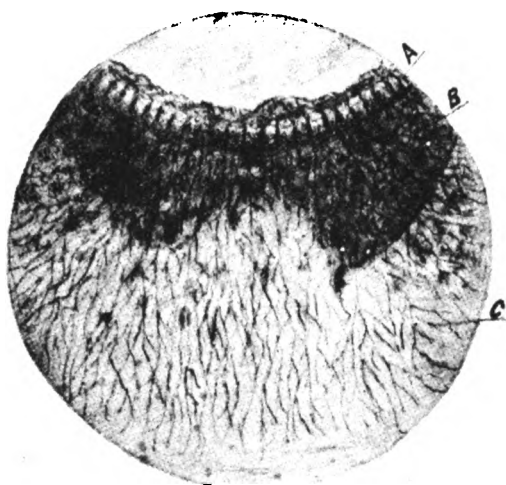


Fig. 18. *Trigonia margaritacea*. Section of shell transverse to ribs.

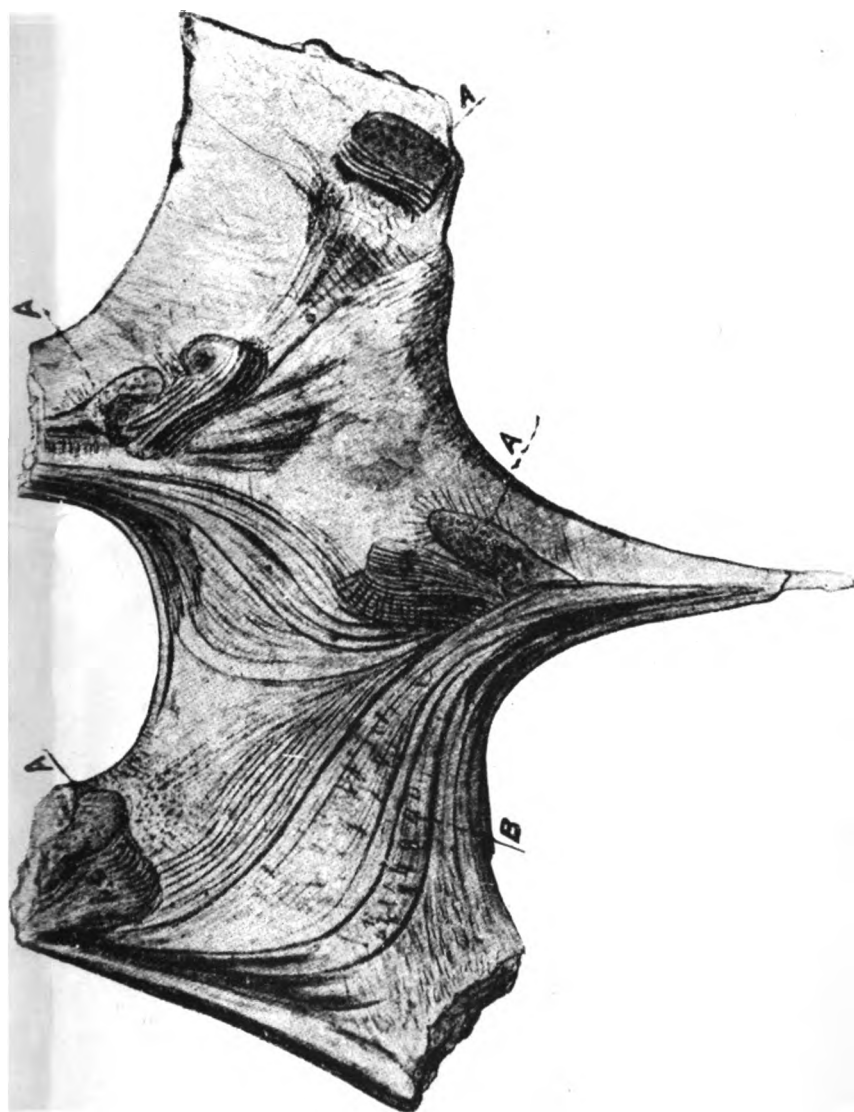


Fig. 19. *Trochus (Uvanilla) tentoriiformis*. Vertical section of columella.



Figs. 20 and 21. Exterior of right and left valve *Trigonía lamarchii*.



Fig. 22. Interior of valve of *Trigonía lamarchii*.



Fig. 23. Interior of valve of *Trigonía margaritacea*.

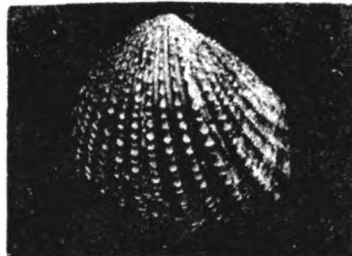


Fig. 24. Exterior of valve of *Trigonía margaritacea*.

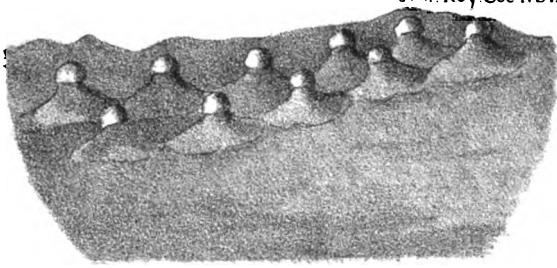


FIG. 25, Outer surface of Trigonía lamarckii, seen obliquely, x 600 diam.

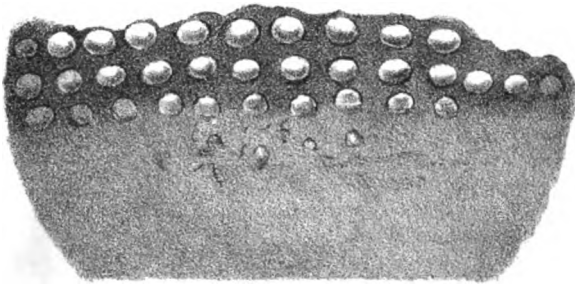


FIG. 26, Surface of a tubercle on ribs of Trigonía lamarckii seen obliquely showing lenses x 300 diameters

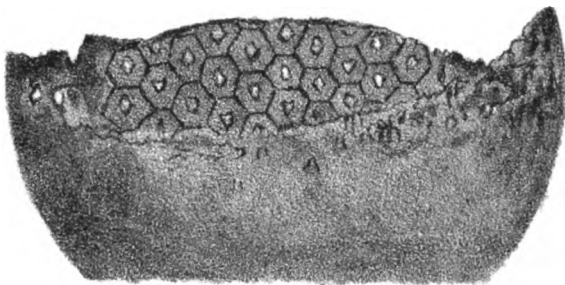
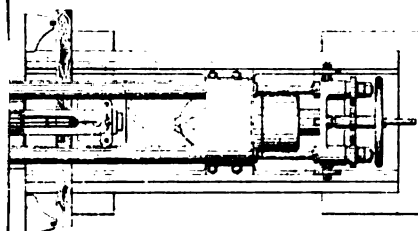
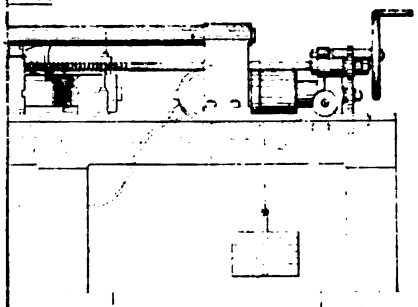


FIG. 27. Surface of the exterior of Trigonía lamarckii seen obliquely x300 This kind of surface is generally seen between the ribs and not showing the projecting lenses.

C. TESTS

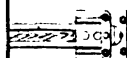


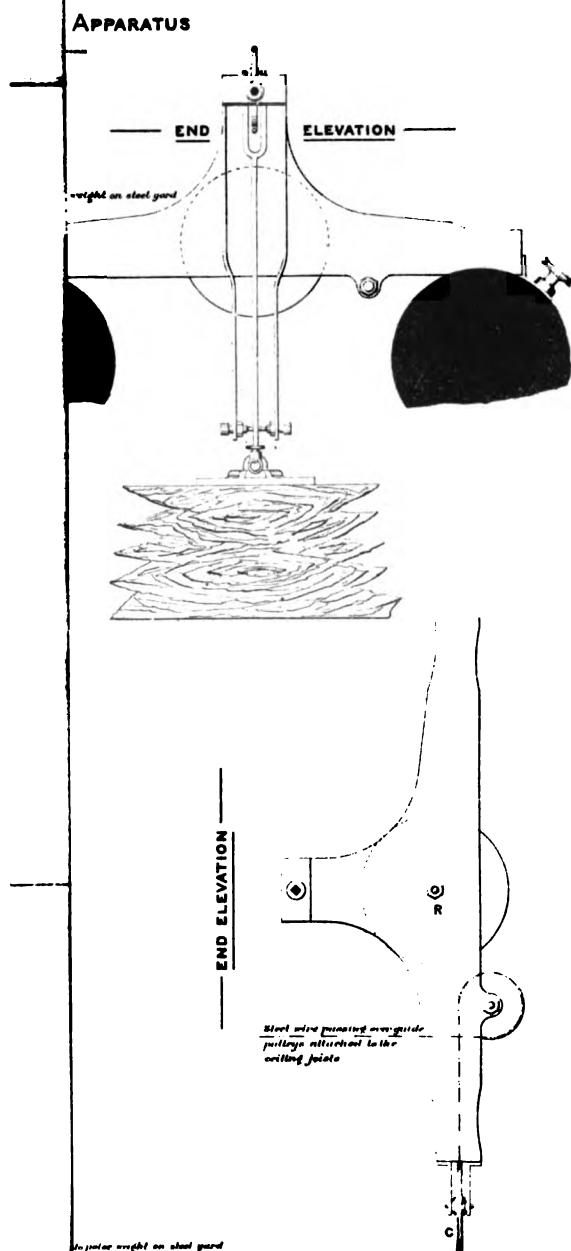
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ELEVATION

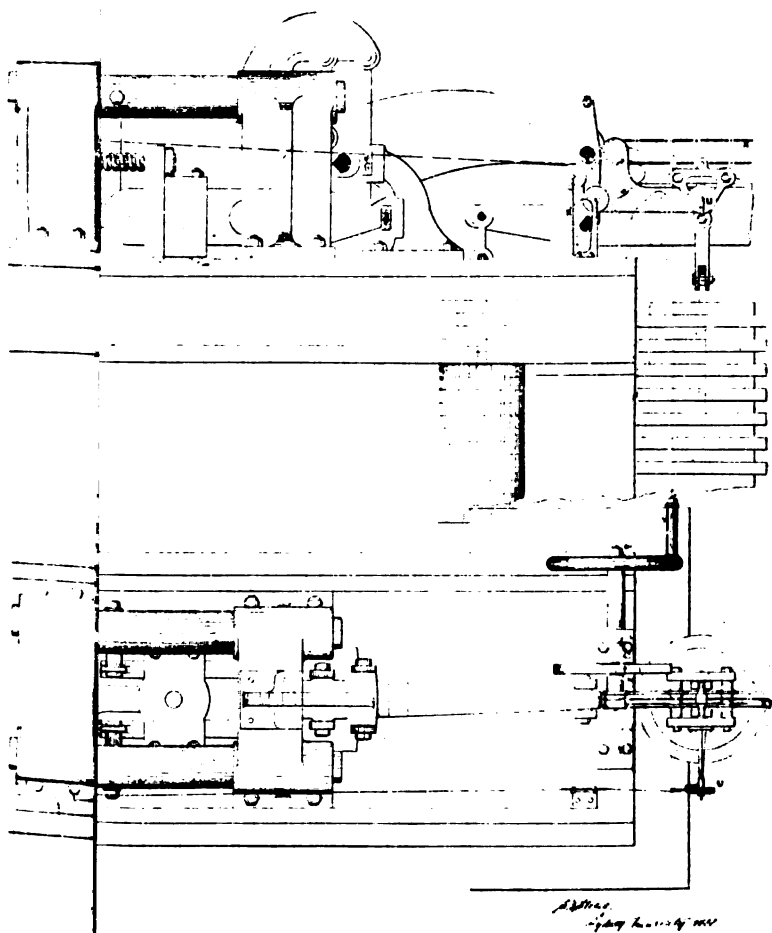


PLAN





ARATUS



N.S.W. TIMBERS

CROSS BREAKING

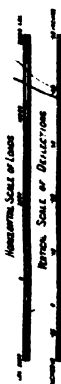
DIAGRAMS SHOWING LOADS AND DEFLECTIONS

Specimen No. / When Tested

1

2

3



GREY IRONBARK
B.1.

RED IRONBARK
B.2.

SPOTTED CUM
B.3.

BLACKBUTT
B.4.

RED CUM

WOOLLYBUTT
B.5.

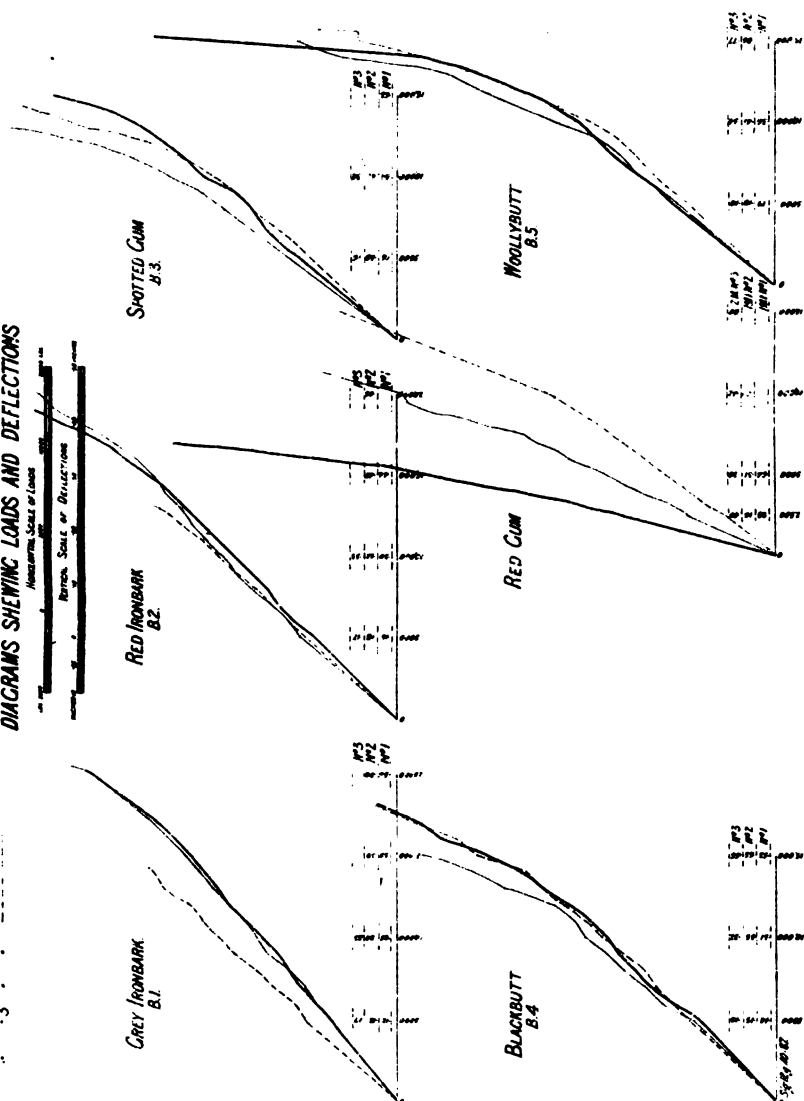




Fig. 1. Prismatic basalt. Glass-house Mountain, Moreton Bay, Queensland.



Fig. 2. Core of Prismatic basalt. Glass-house Mountain, Moreton Bay, Queensland.



Fig. 3. Various Specimens of Volcanic Dust.

- a. Volcanic dust which fell in Norway, March 29th and 30th, 1875.
- b. Volcanic dust erupted from Krakatoa, August 27th, 1883.
- c. Volcanic dust from the Truckee River, Nevada. Quaternary.
- d. Volcanic dust from Brakleest Hill, in Saugus, Mass., pre-Carboniferous.



Fig. 4. Desert Sandstone, Mary River, North Australia, $\times 70$ diam.



Fig. 5. Ash from Bromo crater, Java, $\times 70$ diam., active volcano.







Fig. 7. Hyalite from Lava, Mount Bramble, Springsure, Queensland, $\times 70$.

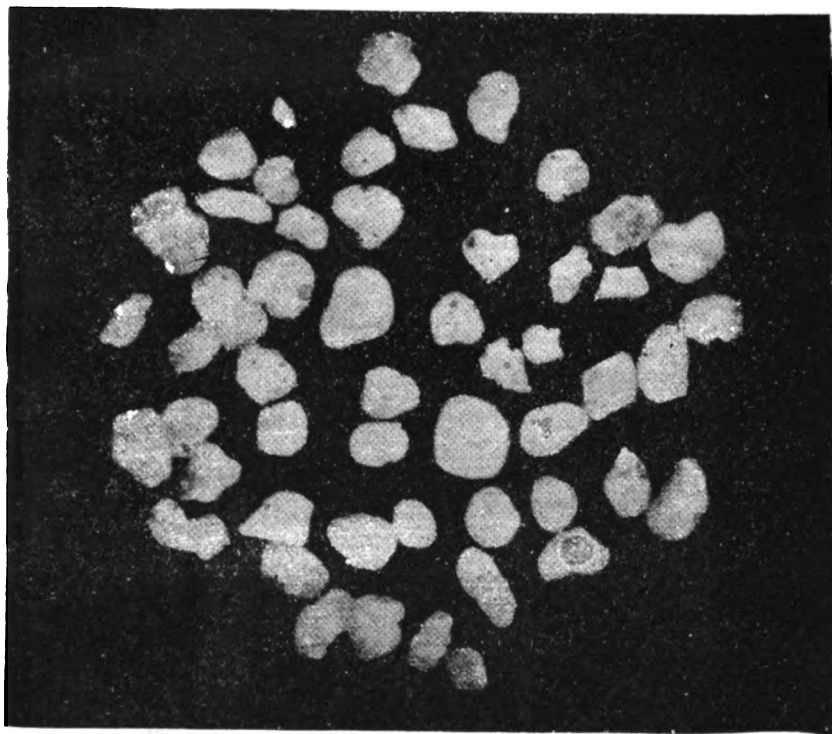


Fig. 8. Desert Sandstone, Yam Creek, North Australia, $\times 50$ diam.

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ETY, N.S.W., 1888. Plate 24. Part II.

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